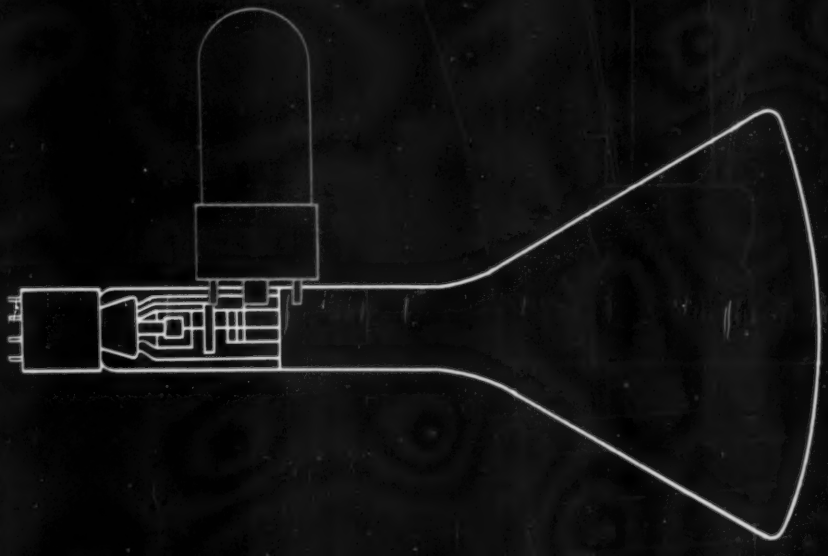
Metal PROGRESS



*PRECISE HEAT TREATING OF TOOLS, DIES AND SMALL PARTS... WITHIN A WIDE TEMPERATURE RANGE!

*For heat treating dies similar to those shown above, one Midwestern die and stamping company relies on the uniform results of the 'Surface' Small Oven Furnace. This firm says, "It's perfect for the job!"

Standard Rated, and equipped with direct-firing burners using the Conjecto-Firing principle, these batch furnaces are ideal for intermittent production, as well as the varied requirements of tool rooms, repair shops, and all other industrial applications. Conjecto-Firing provides a wide temperature range and accurate temperature control. Rapid circulation of an increased volume of hot gases assures rapid and uniform heating at temperatures as low as 600°F. Temperatures up to 2000°F. are also available. This wide operating range results in one 'Surface' furnace doing the job of two ordinary furnaces.

Large oven furnaces, too!

Mighty tough demands are made daily on 'Surface' Small Oven Furnaces. Large Oven Furnaces, too. Both meet these demands perfectly . . for many years with practically no maintenance. 'Surface' Small or Large Oven Furnaces are ideal for your purposes. Surface Combustion's skilled sales engineers will help you apply them. Just write:

'Surface' INDUSTRIAL FURNACES

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

THERMALLOY "30"

A cast heat-resistant alloy with high aged ductility

For service in the 1200°-1600° F. range

WRITE FOR NEW FREE FOLDER

Thermalloy* "30"—a 21% Cr 9% Ni alloy—has outstanding aged ductility characteristics and hot strength equal to that of 25% Cr 12% Ni type alloys. Since its alloy content is lower, Thermalloy "30" is also somewhat more economical.

In tests involving over 100 heats, excellent data has been obtained on stress rupture properties, aged ductility, oxidation resistance and mechanical properties. For additional information write for Bulletin T-211. Electro-Alloys Division, 2092 Taylor St., Elyria, Ohio.

THERMALLOY "30" OFFERS:

Improved Ductility— 18% minimum after aging for 24 hours at 1400° F.

Uniform Strength Levels— equivalent to and more uniform than 25% Cr 12% Ni types.

Greater Economy— since quantity of alloying elements is less than in similar types.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

ELYRIA, OHIO

Around the Clock

PRODUCTION AGAIN WITH SPENCER TURBOS

"In 1942 we moved to our present location and at that time we purchased 2 Spencer Turbine Blowers; these operated 24 hours a day, 7 days a week, until August 1945 and from then until now have operated from 4:30 in the morning 'til 6 o'clock some nights and many nights around the clock. They are both operating at the present time and have never been touched except for oiling. These blowers have been more than satisfactory for continuous operation."

RICHARD W. THORNE
BENNETT STEEL TREATING CO.
NEWARK, N. J.

That's one reason why more than 30 manufacturers of furnaces and ovens prefer Spencer and why the horse-power installed has increased tenfold in ten years.

Other reasons include quiet operation, without vibration—no special foundations, a wide range of standard sizes and special power drives for any location. Your next Turbo is described in Bulletin No. 126-A. Application data in Bulletin No. 107-C.

440-B

35 TO 20,000 C.F.M.; 4 OZ. TO 10 LBS.; 1/3 TO 1,000 H.P.

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER
HARTFORD

3 reports

On the new Steam Homo method for bluing

1 Solves cadmium shortage

The cadmium shortage caught a New England plant with its inventory down. At the suggestion of an L&N field engineer, they used a Steam Homo already in their heat-treat to blue some sample parts. Now, 80% of the parts that were previously cadmium plated on one of their products are blued. When cadmium is again available, they intend to stick with Steam Homo bluing. Close fitting parts operate smoother . . . costs are lower . . . and, they never have to worry about a steam shortage. Another Steam Homo is on order.

2 Eliminates hazards

A large manufacturer of tools didn't like the smell and hazards of the bluing method being used on die stocks and tap wrenches. After a demonstration, the firm switched to the Steam Homo Method. Now, operating people are happy . . . working conditions greatly improved. So many other uses for this versatile furnace have been found that now there are seven Steam Homos . . . with four more on order.

3 Better corrosion resistance

A large midwestern manufacturer tested several methods of bluing stators and rotors of electric motors. Parts were blued, and then placed in a humidity cabinet at 100% humidity and 110 F until red rust appeared. Steam Homo blued parts were still in good shape after three months. The other parts had rusted in less than half this time. Now that the Steam Homo Method is an integral part of their production set-up, their inspectors claim that color uniformity and general appearance are the best they've ever seen.

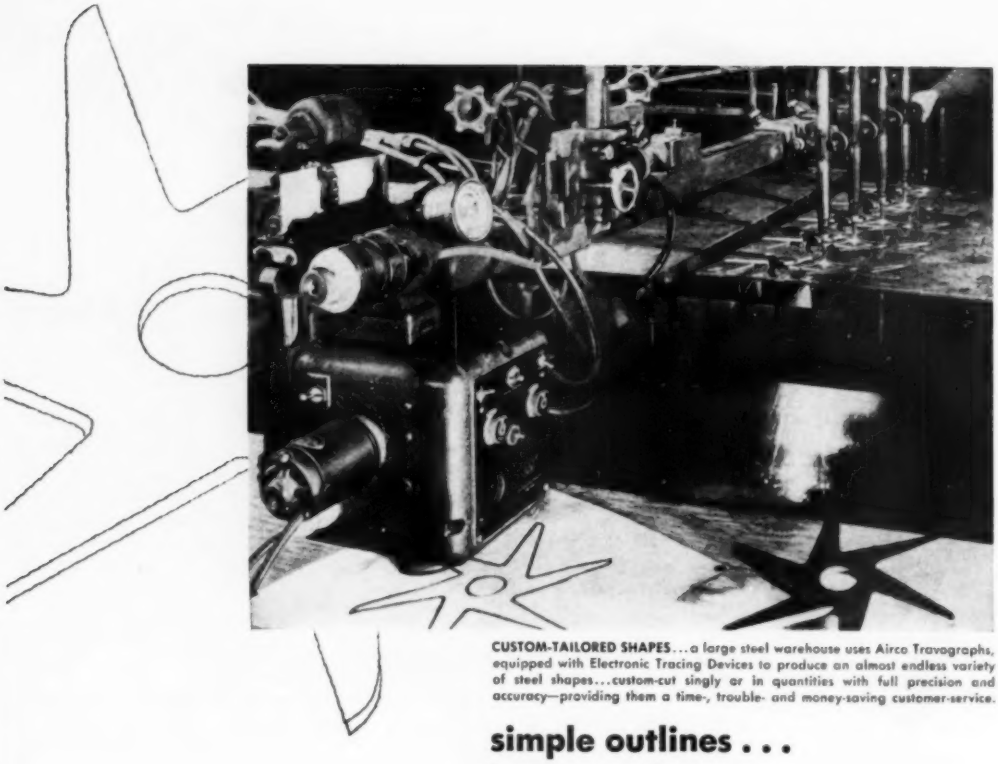
THESE are typical examples of the results plants all over the country are getting with the new Steam Homo Method for bluing. Durable, uniform, corrosion resistant and eye appealing, this type of finish can be applied to any iron or steel product.

Because steam is used as the furnace atmosphere, the process is clean, non-hazardous and inexpensive . . . the Steam Homo can be installed directly in production lines.

To find out what the Steam Homo Method can do for your product, get in touch with the nearest L&N office or write to 4927 Stenton Ave., Philadelphia 44, Pa.

LEEDS NORTHRUP

Jrl Ad T-62034



CUSTOM-TAILORED SHAPES...a large steel warehouse uses Airco Travographs, equipped with Electronic Tracing Devices to produce an almost endless variety of steel shapes...custom-cut singly or in quantities with full precision and accuracy—providing them a time-, trouble- and money-saving customer-service.

simple outlines . . . intricate shapes cut to "AIRCO ACCURACY" *with*

AIRCO'S ELECTRONIC BLOODHOUND

Airco's new electronic tracing device, popularly known as the "Electronic Bloodhound", brings new economy and flexibility to machine gas cutting operations.

Designed for use only on Airco Oxygraph and Travograph gas cutting machines, the "Electronic Bloodhound" needs only an outline drawing or silhouette for a guide. One such low-cost, easily-prepared drawing or silhouette is sufficient whether one, a hundred, a thousand or more parts are to be cut in any design . . . from simplest to most intricate—inside and outside *square* corners, obtuse and acute angles, narrow slots, long slim projections, and many others. The Airco electronic tracing device follows the outline *automatically* to effect such accuracy of cutting that in most cases further machining is unnecessary.

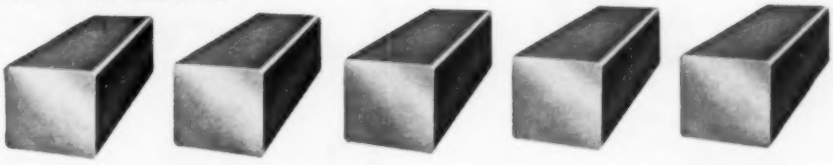
For further data about this outstanding contribution to machine gas cutting, call or write your nearest Airco office today.

AIRCO **AIR REDUCTION**

AIR REDUCTION SALES COMPANY • AIR REDUCTION MAGNOLIA COMPANY
AIR REDUCTION PACIFIC COMPANY
REPRESENTED INTERNATIONALLY BY AIRCO COMPANY INTERNATIONAL
Divisions of Air Reduction Company, Incorporated
Offices in Principal Cities

You get uniform forgings...

bar after bar...



heat after heat...

with TIMKEN® forging steels

FROM bar to bar and heat to heat, Timken® forging steels give you uniform forgeability, plus superior surface and internal quality. Result: better forgings at lower cost.

Because Timken forging steels give you uniform chemical and physical properties, uniform response to heat treatment, and uniform machinability, rejects are reduced. You have fewer delays and shop practice changes. And the performance of your forgings is consistently excellent.

You're certain of all these advantages because Timken forging steels are tailor-made to your specification, with quality carefully controlled at every step in production. For an on-the-job analysis of your forging problem, ask for the help of our Technical Staff. There's no obligation. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing

Enduro®

TAKES A "BITE" OUT OF HIGH MACHINING COSTS

● ENDURO Stainless Steel takes a shine to dentists.

In dental hand-pieces—precisely machined from ENDURO forgings—it retains its bright shining lustre despite day-after-day sterilizing. ENDURO instruments are sanitary; free from rust, corrosion and oxidation; tough and long-lasting.

ENDURO responds uniformly to forging—and, as these intricate parts indicate, is readily machinable.

In addition, ENDURO Cold Finished Bars—processed by Republic's Union Drawn Steel Division—provide close tolerances, accuracy of section, uniform soundness and fine surface finish. Two grades are approximately 90% as machinable as Bessemer screw stock. All these qualities combine to hold unit costs and reject losses for stainless steel parts to lowest possible levels.

Republic metallurgists and machining technicians are ready now to help you take large "bites" out of high machining costs through the proper application of ENDURO free-machining bars—both hot rolled and cold drawn. Write:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

Republic ENDURO® FREE-MACHINING STAINLESS STEEL

REPUBLIC STEEL

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Yes! AJAX Induction Melting Furnaces are Versatile!

For many years AJAX has been the pioneer in the development of standard frequency induction furnaces for melting metals. Today this type of equipment has been adapted to the full range of non-ferrous metals and alloys and to a great variety of sizes ranging from 20 to 1000 kW.

AJAX Induction Melting Furnaces are now used for the following applications: Die Castings, Permanent Mold Castings, Sand Castings, Billets for Rolling and Extrusion, Recovery of Scrap, Galvanizing and Aluminizing of Steel and many others.

For special applications an Automatic Electromagnetic Pump allows continuous feeding of molten metal into the molds as they move past. Hand ladling is eliminated. Temperature of course is also automatically controlled and there is no chance of overheating the bath at any time during the melting cycle.

Write For Further Information

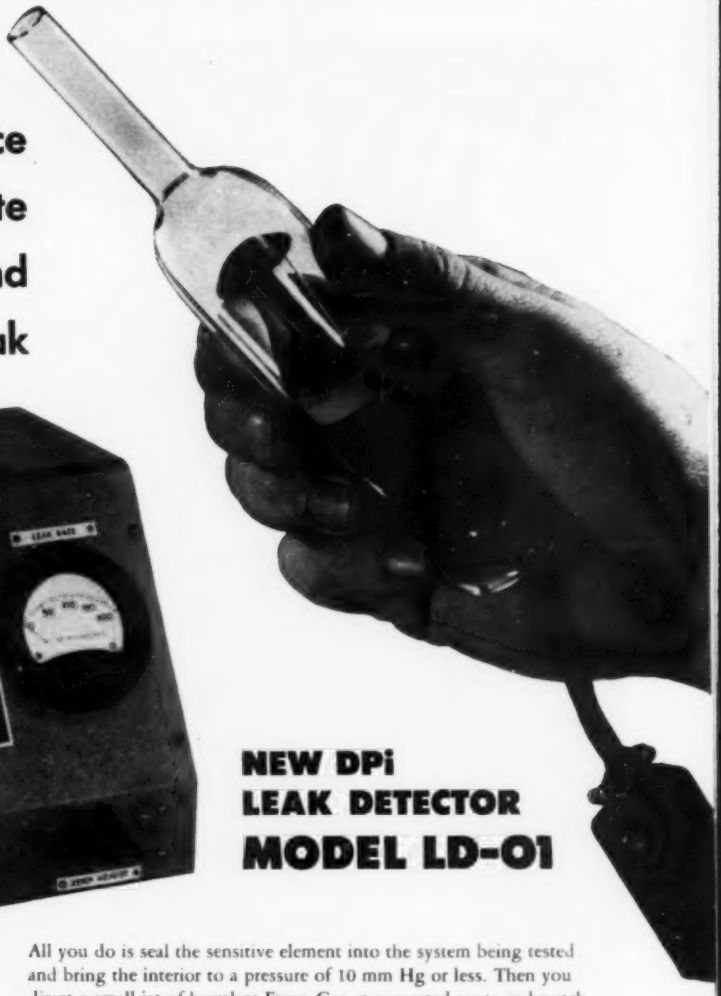
AJAX ENGINEERING CORPORATION, TRENTON 7, N. J.

AJAX TAMA-WYATT

INDUCTION MELTING FURNACE

AJAX ELECTRO METALLURGICAL CORP., and Associated Companies
AJAX ELECTROTHERMIC CORP., Ajax Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting

here's a simple device to locate almost any kind of leak



NEW DPi LEAK DETECTOR MODEL LD-01

All you do is seal the sensitive element into the system being tested and bring the interior to a pressure of 10 mm Hg or less. Then you direct a small jet of harmless Freon Gas at suspected spots and watch the meter. It's as simple as that, and sensitivity is high enough even where one-millionth of atmospheric pressure is to be maintained.

It works like this: The sensitive element contains a heated platinum anode and a cold cathode with relatively low voltage between them. The tendency of hot platinum to emit positive ions is enormously stimulated by infinitesimal traces of halogens or their compounds. The circuit to accomplish all this uses only three standard radio tubes and operates from your 115-v a-c lighting circuit.

For full information write ***Distillation Products Industries,*** Vacuum Equipment Department, 753 Ridge Road West, Rochester 3, N. Y. (Division of Eastman Kodak Company).

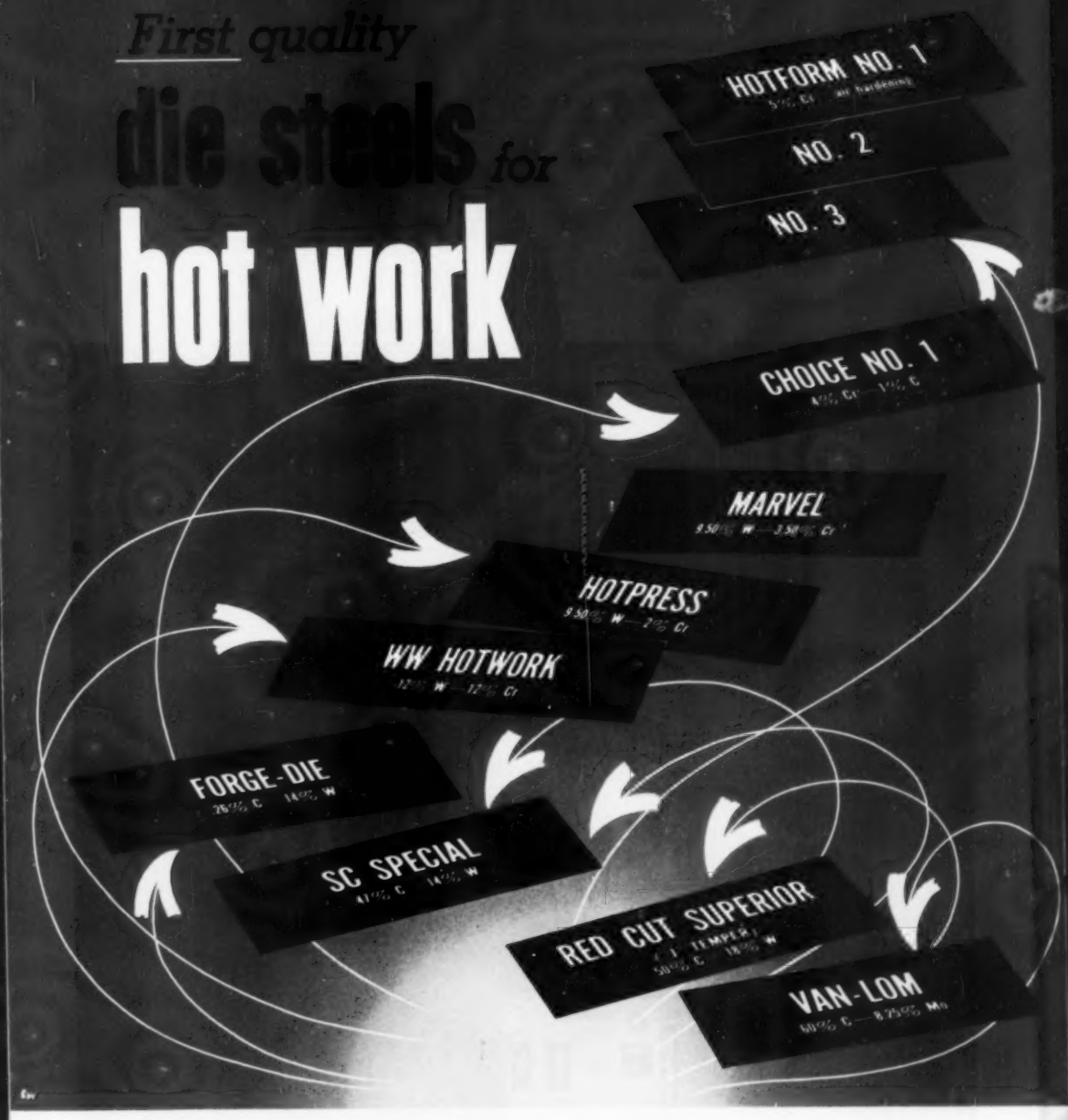
DPi

high vacuum research and engineering

Also . . . high vacuum equipment . . . distilled monoglycerides . . . more than 3400 Eastman Organic Chemicals for science and industry

First quality

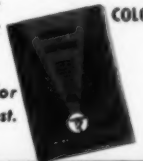
die steels *for* hot work



These Die Steels are designed to meet your every hot work requirement. They are made to exacting standards and inspected by magnaflux, reflectoscope and deep etching to insure First Quality Steels. All grades are available in bars and forgings.

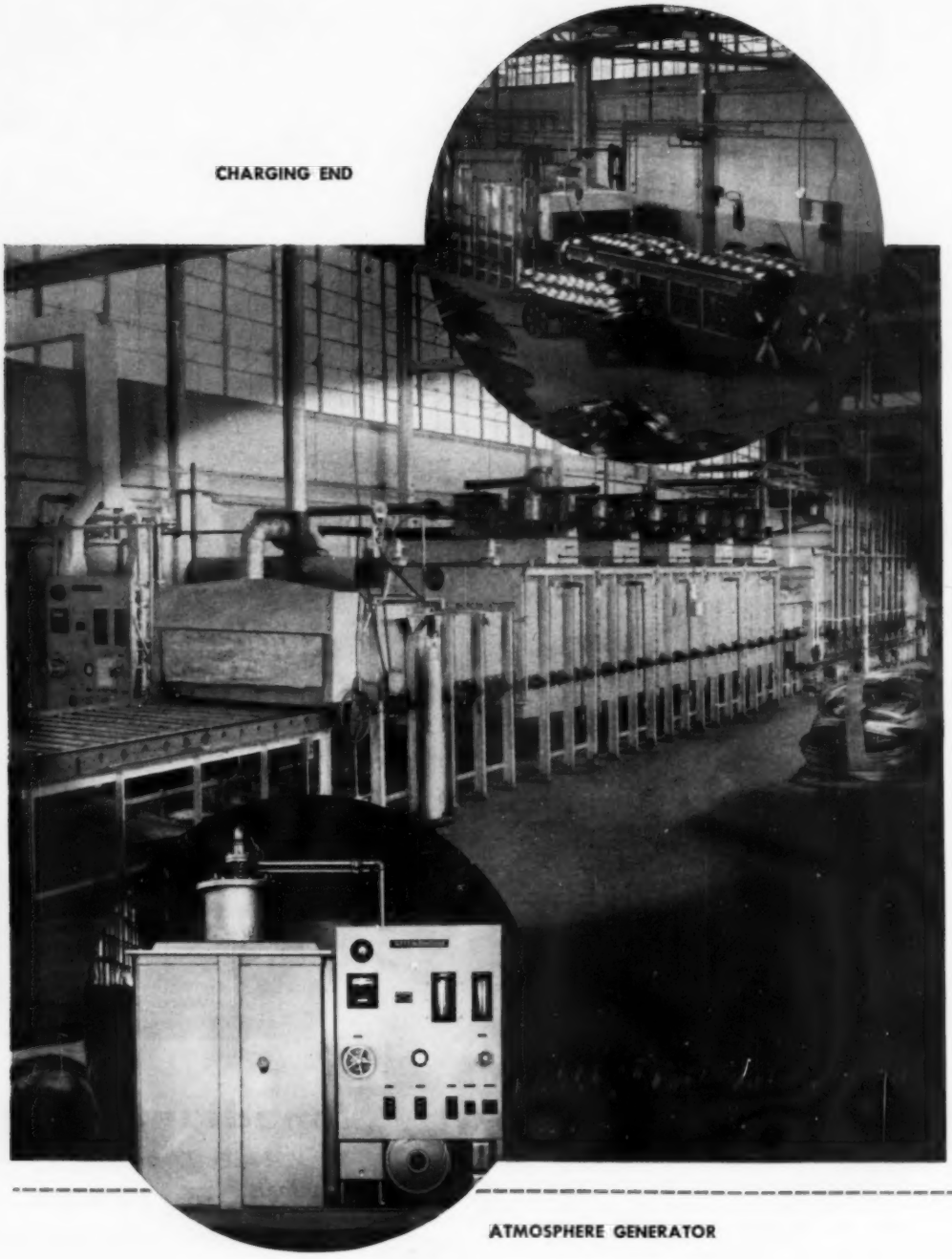
Our sales representatives will be glad to work with you in selecting the best grade for your particular job and in the correct heat treatment for maximum performance.

Booklet "Die Steels for Hot Work" sent on request.



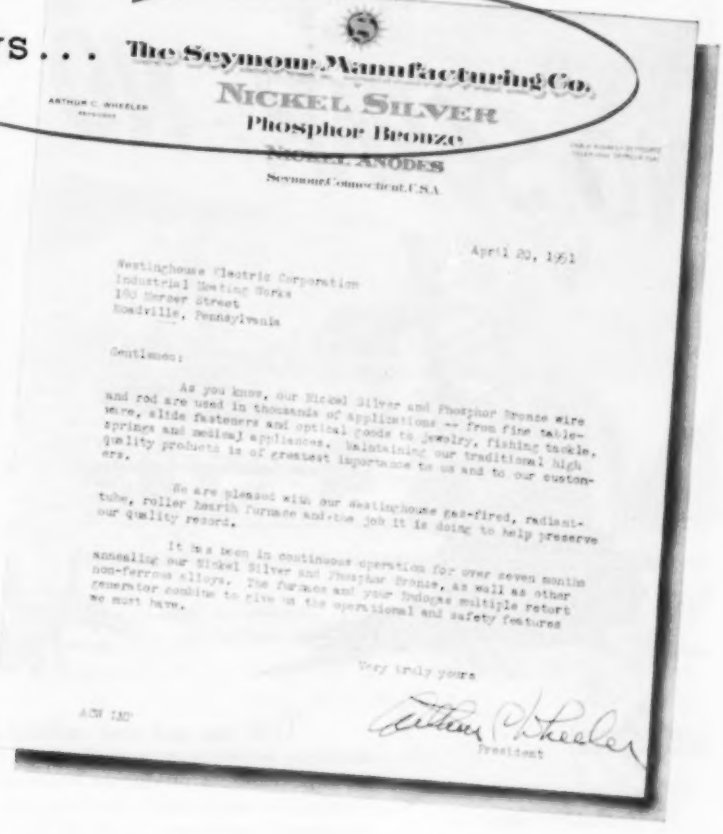
Vanadium-Alloys
STEEL COMPANY
LATROBE, PENNA.

COLONIAL STEEL DIVISION · ANCHOR DRAWN STEEL CO.


CHARGING END
ATMOSPHERE GENERATOR

"Gives us operational and safety features we must have"

says . . . The Seymour Manufacturing Co.


NICKEL SILVER
Phosphor Bronze
NICKEL ANODES
Seymour, Connecticut, U.S.A.

April 20, 1951

Westinghouse Electric Corporation
Industrial Heating Works
180 Mercer Street
Meadville, Pennsylvania

Gentlemen:

As you know, our Nickel Silver and Phosphor Bronze wire and rod are used in thousands of applications -- from fine tableware, slide fasteners and optical goods to jewelry, fishing tackle, springs and medical appliances. Maintaining our traditional high quality products is of greatest importance to us and to our customers.

We are pleased with our Westinghouse gas-fired, radiant-tube, roller hearth furnace and the job it is doing to help preserve our quality record.

It has been in continuous operation for over seven months annealing our Nickel Silver and Phosphor Bronze, as well as other non-ferrous alloys. The furnace and your Endogas multiple retort generator combine to give us the operational and safety features we must have.

Very truly yours

Arthur C. Wheeler
President

ACW:MD

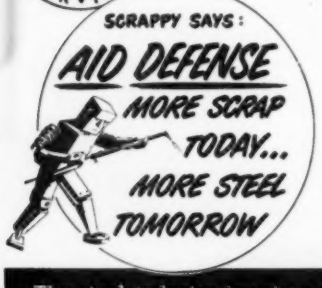
Gas-fired or electric, there's a Westinghouse Furnace to meet every heat-treating need. Select from a wide variety of standard units; or special designs can be prepared to meet particular needs. It's your assurance of an unbiased answer to your all-important problem. Westinghouse Electric Corporation, Industrial Heating Division, Meadville, Pennsylvania. J-10370

YOU CAN BE SURE...IF IT'S
Westinghouse
HEAT-TREATING FURNACES

IF YOUR PRODUCT CALLS FOR HEAT-TREATING . . . IT CALLS FOR A WESTINGHOUSE FURNACE . . . GAS OR ELECTRIC

NO SCRAP... NO STEEL!

QUALITY
YOUNGSTOWN
SERVICE



THE iron and steel industry faces a serious scrap shortage, growing more critical every day. . . . It will be impossible for producers to make the steel tonnages demanded for rearmament and essential civilian needs, unless consumers cooperate by furnishing *more scrap*. . . Most desperately needed now is heavy industrial iron and steel scrap. . . . Keep the cobwebs from gathering at your own plant by turning in more of your own scrap today.

The Youngstown Sheet and Tube Company

General Offices—Youngstown 1, Ohio
Export Offices—500 Fifth Avenue, New York
MANUFACTURERS OF CARBON ALLOY AND YOLOY STEELS

The steel industry is using all its resources to produce more steel, but it needs your help and needs it now. Turn in your scrap, through your regular sources, at the earliest possible moment.

X.... Eliminated
This 20 KW, 450,000 cycle TOCCOtron tube oscillator unit handles 600 transmission nuts per hour.
LABOR COSTS Cut 78%

with TOCCO* Induction Heating

THE JOB—International Harvester Company, world-famous builder of farm machinery, uses TOCCO for the selective hardening of the special tractor transmission nut shown above. Only the contact surfaces are hardened. The bottom channel must remain soft or the part will crack, and any distortion would affect the threads. Material is C-1045 steel; production required 600 per hour.

THE RESULTS—Formerly the part was copper-plated before milling the slot. Then the slot was milled, the part carburized and hardened in a batch-type furnace. Finally the parts had to be cleaned and the threads rechased after hardening to assure proper fit. Now the adoption of TOCCO hardening eliminates these operations, stops distortion and saves $3.50 for every batch of 600 pieces.

● This job, typical of thousands of cost-saving TOCCO installations all over the world, may suggest ways you can reduce costs and speed production on hardening, brazing, annealing, forging or melting jobs in your own plant. Experienced TOCCO engineers are glad to work with you—without obligation, of course—for similar cost-cutting results.

THE OHIO CRANKSHAFT COMPANY

NEW FREE BULLETIN

Mail Coupon Today

THE OHIO CRANKSHAFT CO.
Dept. R-11, Cleveland 1, Ohio

Please send copy of 60-page catalog "TOCCO Induction Heating."

Name_____

Position_____

Company_____

Address_____

City_____ Zone____ State____

Going around in circles?

UNDECIDED on what copper alloy rod to use?

. . . here's a suggestion from CHASE

Which rod is your best choice for fast production . . . for bending and forming . . . for corrosion resistance? Which should you use for hot forging . . . cold working . . . longer tool life? Which gives you strength . . . electrical or thermal conductivity?

For information like this write us today. We'll send you helpful literature on Copper Alloy Rods covering:

- Composition
- Forms and Sizes
- ASTM Specifications
- Relative Machinability
- Tensile and Yield Strengths
- Coefficients of Expansion
- Rockwell Hardness
- Elongation
- Shear Strength
- Electrical and Thermal Conductivity
- Melting Range
- Weldability

SEND FOR COMPLETE INFORMATION
Just check the literature you would like, fill in your name and address and mail coupon.

Chase Brass & Copper Co., Dept. MP 1151
Waterbury 20, Conn.

Please send me: ☐ Free-Cutting Brass, Bronze, Copper Book; ☐ Weight Chart; ☐ Decimal Equivalent Card; ☐ Chart of Free-Cutting Copper Alloys; ☐ Tellurium Copper Book; ☐ Telnic Bronze Book; ☐ Phosnic Bronze Book; ☐ Chase Phosphor Bronze Folder

Name _____

Position _____

Firm _____

Address _____

City _____ State _____

Chase BRASS & COPPER

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

CHASE 75th ANNIVERSARY 1876 1951

• *The Nation's Headquarters for Brass & Copper*

Albany†	Cleveland	Kansas City, Mo.	New York	San Francisco
Atlanta	Dallas	Los Angeles	Philadelphia	Seattle
Baltimore	Denver†	Milwaukee	Pittsburgh	Waterbury
Boston	Detroit	Minneapolis	Providence	
Chicago	Houston†	Newark	Rochester†	(Trailer office only)
Cincinnati	Indianapolis	New Orleans	St. Louis	

SALT BATH BRAZING

...the fastest, cheapest production method!

✔ ***Work immersed in batches*** ... 5, 20 or 100 assemblies in each batch.

✔ ***All joints brazed simultaneously*** ... in seconds rather than in minutes.

✔ ***Decarburization of steel assemblies avoided*** ... no reheating needed. Clean surfaces assured for subsequent processing.

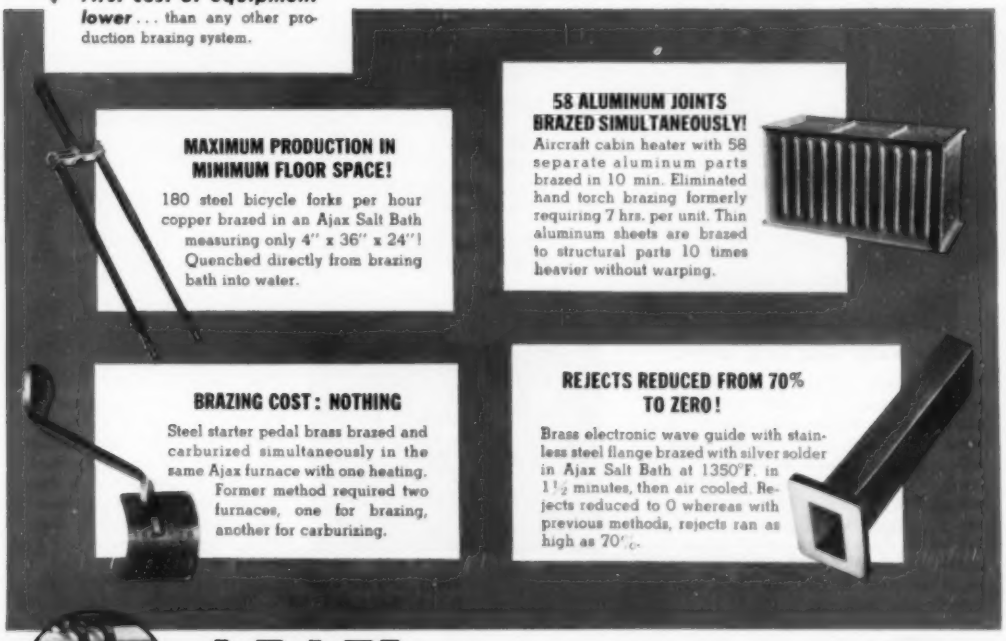
✔ ***No cooling chamber required*** ... no hydrogen atmosphere. 75% less floor space!

✔ ***First cost of equipment lower*** ... than any other production brazing system.

Ajax pioneered the salt bath brazing technique and proved that most ferrous or non-ferrous assemblies in production quantities can be brazed far faster and more economically by this method than by any other. Today this method is widely used by leading fabricators on a wide variety of work for brazing steel, cast iron, copper or aluminum assemblies.

In cases where a brazed assembly must also be hardened or carburized, the salt bath offers special economies because the brazing and hardening can be done simultaneously in a single heating operation.

Let us braze a job batch of your parts in our Metallurgical Service Laboratory. See how much faster your work can be handled, how much your product can be improved. Write for details.



MAXIMUM PRODUCTION IN MINIMUM FLOOR SPACE!

180 steel bicycle forks per hour copper brazed in an Ajax Salt Bath measuring only 4" x 36" x 24"! Quenched directly from brazing bath into water.

58 ALUMINUM JOINTS BRAZED SIMULTANEOUSLY!

Aircraft cabin heater with 58 separate aluminum parts brazed in 10 min. Eliminated hand torch brazing formerly requiring 7 hrs. per unit. Thin aluminum sheets are brazed to structural parts 10 times heavier without warping.

BRAZING COST: NOTHING

Steel starter pedal brass brazed and carburized simultaneously in the same Ajax furnace with one heating. Former method required two furnaces, one for brazing, another for carburizing.

REJECTS REDUCED FROM 70% TO ZERO!

Brass electronic wave guide with stainless steel flange brazed with silver solder in Ajax Salt Bath at 1350°F. in 1½ minutes, then air cooled. Rejects reduced to 0 whereas with previous methods, rejects ran as high as 70%.

SELF-INSTRUCTING • SELF-CIRCULATING

AJAX ELECTRIC SALT BATH FURNACES

AJAX ELECTRIC COMPANY, Inc. 910 Frankford Avenue, Philadelphia 23, Pa.

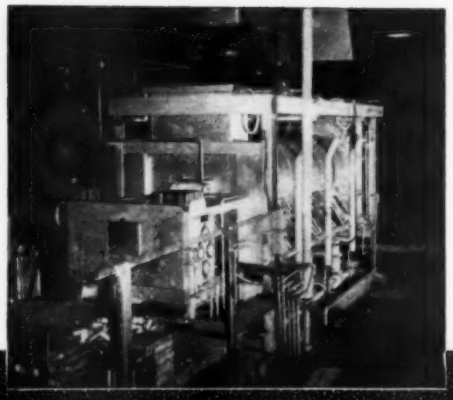
THE WORLD'S LARGEST MANUFACTURER OF ELECTRIC HEAT TREATING FURNACES EXCLUSIVELY

In Canada: Canadian General Electric, Co., Ltd., Toronto, Ont.

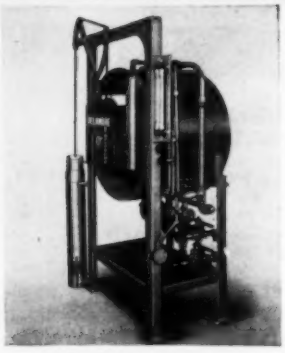
Associate Companies: Ajax Electro Metallurgical Corp. • Ajax Electric Furnace Corp. • Ajax Electrothermic Corp. • Ajax Engineering Corp.

SURFACE COMBUSTION CORP.

This high speed billet-heating furnace used for production forging is fired with gas. Two different Super Refractories are used—ALFRAX BI fused alumina and MULLFRAX electric furnace mullite products. The MULLFRAX material, being very dense, and possessing high hot load strength, is used in the piers supporting the water-cooled skid rails. ALFRAX BI material is used in the main lining because it successfully withstands the high temperatures and flame erosion. Both of these Super Refractories are relatively good insulators and require little backing up material.



You'll find Super Refractories by CARBORUNDUM in nearly every heat-treating furnace



DELAWARE TOOL STEEL CORP.

The CARBOFRAX silicon carbide muffle of this controlled atmosphere furnace provides fast and uniform heat transfer. It also assures a long-lasting muffle, free from cracking. Inside the muffle is a replaceable hearth which is very resistant to abrasion since it is made of CARBOFRAX material. The combustion chamber lining, exhaust ports, door facing, tunnel tile and flame block are all made of MULLFRAX shapes. This material has the necessary resistance to high heat, is not prone to spall and crack, and is a relatively good insulator.

Leading furnace manufacturers use Super Refractories extensively . . . particularly where there are exacting furnace conditions like these:

- **Severe abrasive wear.**
- **Heat shock caused by rapid temperature changes.**
- **Heavy loads—particularly at high temperatures.**
- **Flame impingement and erosion.**
- **Fast, uniform heat transfer to work. Or, insulation of other furnace areas.**

For specific examples of recommended applications, write today for our 40-page booklet. No obligation, much valuable information.

THE SENTRY COMPANY

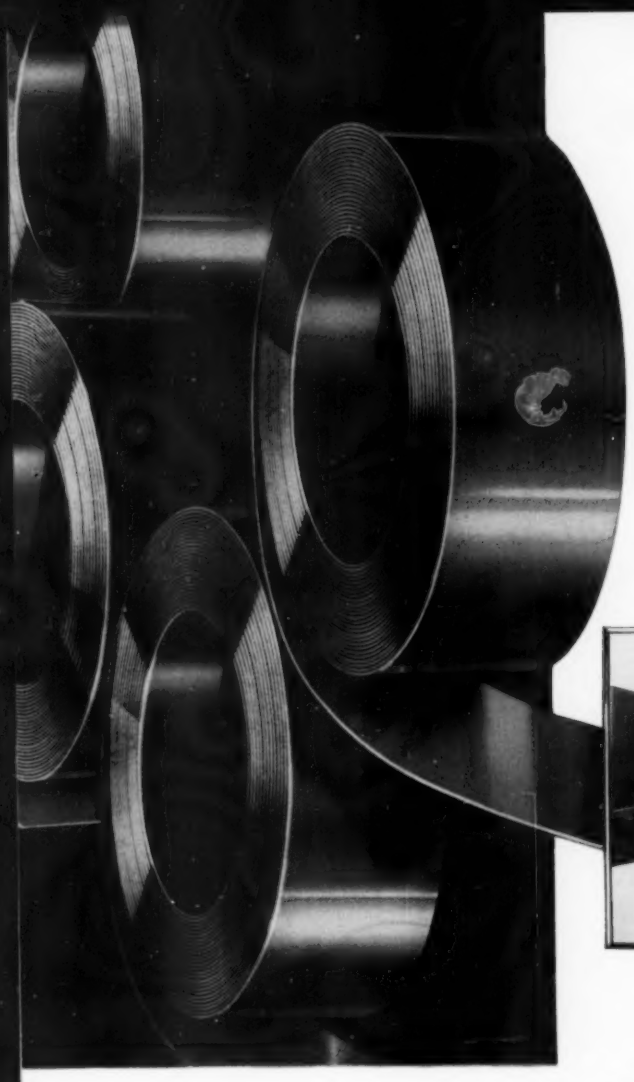
These electrically heated furnaces are used primarily for treating small parts. The furnaces are equipped with CARBOFRAX muffles, baffles and cover plates. The unique properties of CARBOFRAX material—high thermal conductivity, high refractoriness, resistance to thermal shock—assure efficient furnace operation and long-lasting refractory parts. The trays which carry the work are also made of CARBOFRAX material. Because they have to go rapidly from room temperature to furnace heat and back to room temperature again, the heat shock is severe. Nevertheless, these trays stand up extremely well.

THE CARBORUNDUM COMPANY

Dept. C-111 Refractories Div.

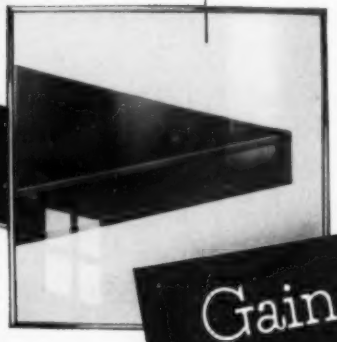
Perth Amboy, N. J.

"Carborundum," "Alfrax," "Carbofrax," and "Mullfrax" are registered trademarks which indicate manufacture by The Carborundum Company.



where **copper's face value** counts

and **steel's** strength and economy are needed . . .



Gain both

with

SuVeneer®

COPPER CLAD METAL

SuVeneer Clad Metal gives you copper bonded inseparably to plain steel strip, on one or both sides . . . providing the advantages of all-copper surfaces, while saving solid copper for defense needs. Your costs are lower with SuVeneer Clad Metal, wherever it can take the place of solid copper . . . and your product performance is increased with the added strength of steel!

Write to our Sales Department for fuller information on SuVeneer Clad Metal, and any assistance you may desire in developing projected applications. No obligation of any kind.

Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

Electric Brazing and Sintering Furnace by HARPER

equipped with

GLOBAR Heating Elements

by

CARBORUNDUM

TRADE MARK

Provides 3-way Advantage

1. Performance

Maximum brazing efficiency, dependable operation and low maintenance costs for extended periods highlight a list of advantages including fast heating, accurate temperature control and uniform work chamber temperatures.

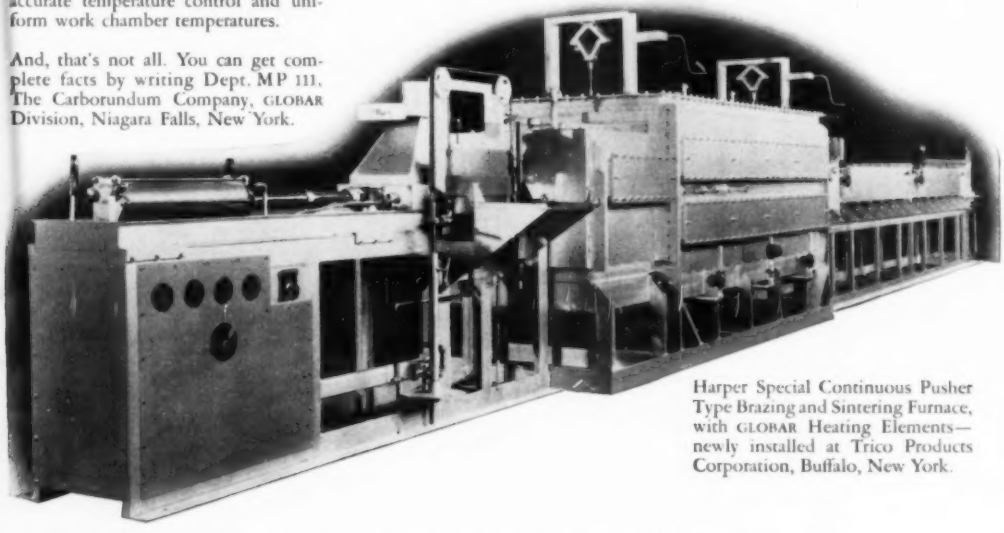
And, that's not all. You can get complete facts by writing Dept. MP 111, The Carborundum Company, GLOBAR Division, Niagara Falls, New York.

2. More Efficient Furnace Design

Made possible by rod-shaped GLOBAR silicon carbide elements which permit larger work chamber space.

3. Easy Maintenance

Elements are interchangeable . . . can be replaced easily, without shutting down furnace.



Harper Special Continuous Pusher Type Brazing and Sintering Furnace, with GLOBAR Heating Elements—newly installed at Trico Products Corporation, Buffalo, New York.

"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

DURABLE...

- Generous Sized Cabinets
- Conditioned Cooling System
- Built-In Checklite System
- Oversized Components
- Filament Voltage Regulation
- Industrial Type Tubes

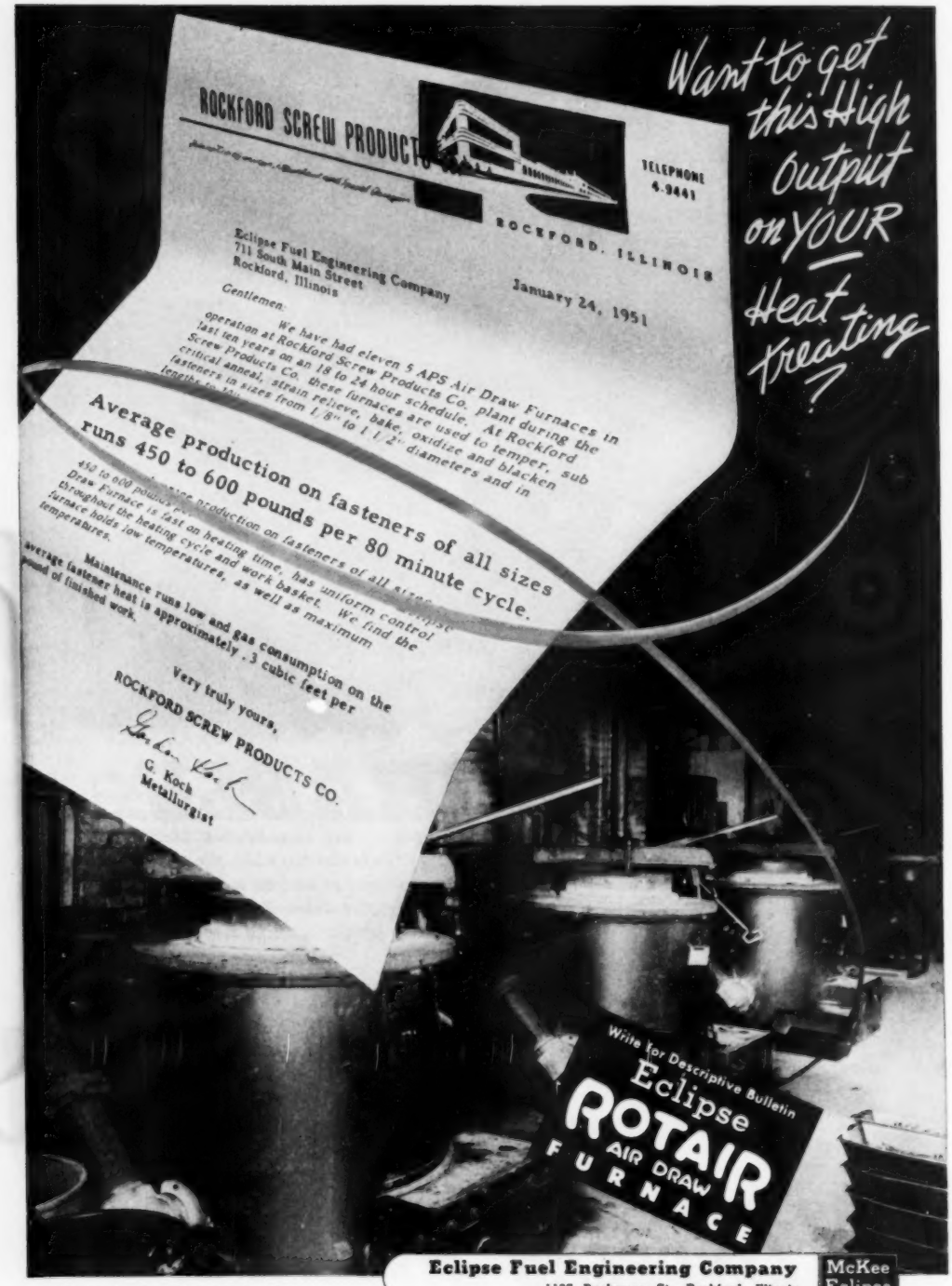
Durable industrial type tubes—shortened and strengthened internal structure for greater mechanical strength — Kovar metal-to-glass seals to withstand greater thermal shock.

Rugged . . . durable . . . and dependable! Lindberg Induction Heating Units are built like the clipper ship captains of old, who had to be iron men to sail their wooden ships. They give dependable 24 hour a day service under heavy production line requirements. Designed for service . . . day after day . . . month after month . . . far beyond the usual capabilities of Induction heating equipment.

For fast, accurate, versatile selective hardening—controlled in both depth of penetration and area covered—investigate the Lindberg Induction Heating Units. Performance records from plants throughout the nation show 24 hour a day operation—day after day—month after month. Ask for Bulletin 1440.

LINDBERG HIGH FREQUENCY DIVISION

Lindberg Engineering Company, 2448 W. Hubbard Street, Chicago 12, Illinois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ROCKFORD SCREW PRODUCTS
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Eclipse Fuel Engineering Company
711 South Main Street
Rockford, Illinois
January 24, 1951
Gentlemen:
We have had eleven 5 APS Air Draw Furnaces in operation at Rockford Screw Products Co. plant during the last ten years on an 18 to 24 hour schedule. At Rockford Screw Products Co. these furnaces are used to temper, sub critical anneal, strain relieve, bake, oxidize and blacken fasteners in sizes from 1/8" to 1 1/2" diameters and in
Average production on fasteners of all sizes runs 450 to 600 pounds per 80 minute cycle.
Draw Furnace is fast on heating time, has uniform control throughout the heating cycle and work basket. We find the furnace holds low temperatures, as well as maximum temperatures.
Maintenance runs low and gas consumption on the average fastener heat is approximately .3 cubic feet per pound of finished work.
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Portion of the battery of Eclipse ROTAIR AIRDRAW FURNACES in Rockford Screw Products Plant

"Putting Mettle into Metals Since 1896"

BELMONT METALS

Metals are our business—and yours too! Today our common problem is the shortage of all metals—the pressure of the civilian economy and defense demands is more than available supply can stand . . . up to the minute "know how" and time tested experience is more important than ever.

Better than half century of service and growth in all periods—War, Peace, "National Emergencies"—have "experienced" Belmont to cope with the current perplexities and problems. When that shortage strikes—or you wish to compare the merits of a substitute—contact Belmont . . . No effort will be spared to add Belmont experience and "know how" to yours—and that "probable" bottleneck can be smashed before it becomes serious.

"Belmont Metal of the Month" letters include market trends, statistics, and other helpful data—write to receive your copy—with our compliments.

Belmont SMELTING & REFINING WORKS, INC.

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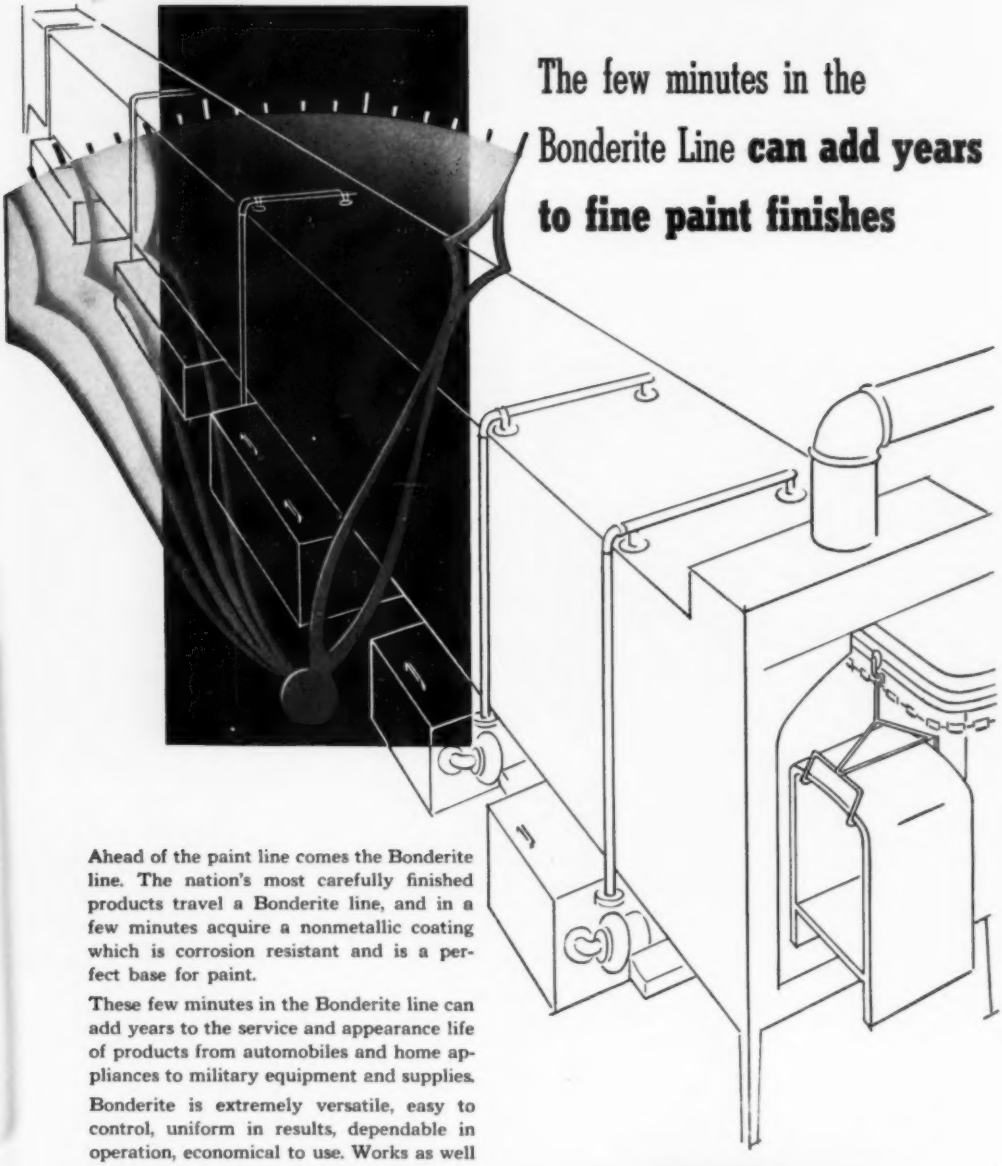

The few minutes in the Bonderite Line **can add years to fine paint finishes**

Ahead of the paint line comes the Bonderite line. The nation's most carefully finished products travel a Bonderite line, and in a few minutes acquire a nonmetallic coating which is corrosion resistant and is a perfect base for paint.

These few minutes in the Bonderite line can add years to the service and appearance life of products from automobiles and home appliances to military equipment and supplies.

Bonderite is extremely versatile, easy to control, uniform in results, dependable in operation, economical to use. Works as well in immersion tanks for limited production as on the largest mass production lines.

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**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

BONDERITE—corrosion resistant paint base

BONDERITE and BONDERLUBE—aids in cold forming of metals

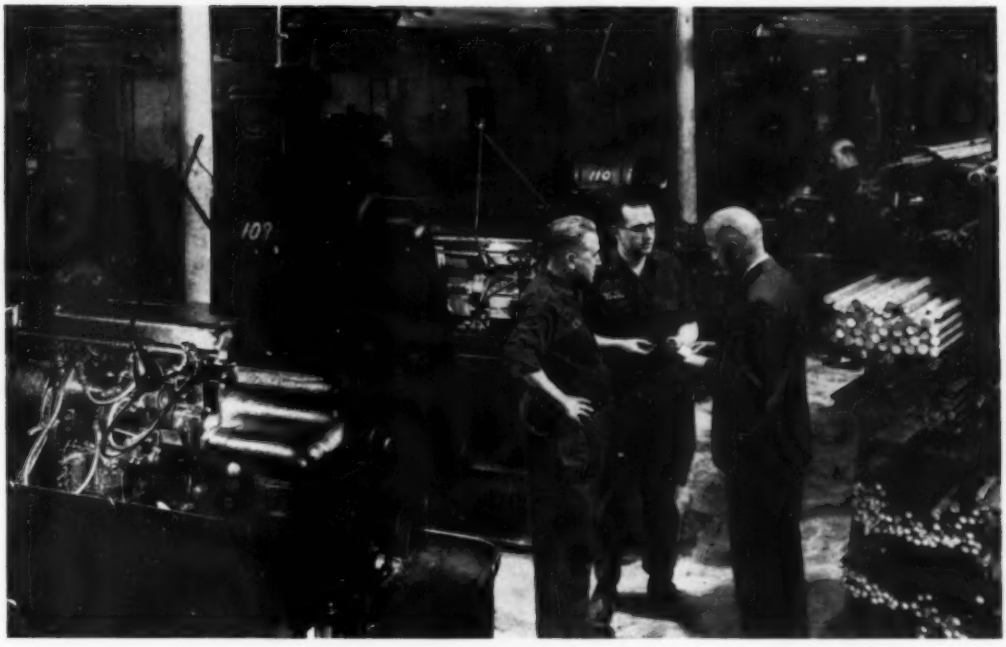
PARCO COMPOUND—rust resistant

PARCO LUBRITE—wear resistant for friction surfaces

"With **Gulf Electro Cutting Oil**

we increased tool life from 5 to 8½ hours on stainless steel races"

says Herman Busch
President, Buswell Metal Products, Inc.



"We've found that the new Gulf Electro Cutting Oil is ideal for all-round service on 6-spindle automatics," says Mr. Herman Busch, President, Buswell Metal Products, Inc., Kensington, Conn. "On tough stainless steel ball races, for example, we've increased tool life from 5 to 8½ hours and we're getting excellent finishes with this outstanding cutting oil."

This is typical of reports from the scores of plants which have made some improvement in production or tool life through the use of Gulf Electro Cutting Oil, the new sulphurized cutting oil that, because of greater sulphur activity, provides better protection for the tool.

Call in a Gulf Lubrication Engineer today and let him help you find opportunities for reducing machining costs through the use of one or more of the quality cutting oils in Gulf's complete line. Get in touch with your nearest Gulf office. Or send the coupon below for further information.

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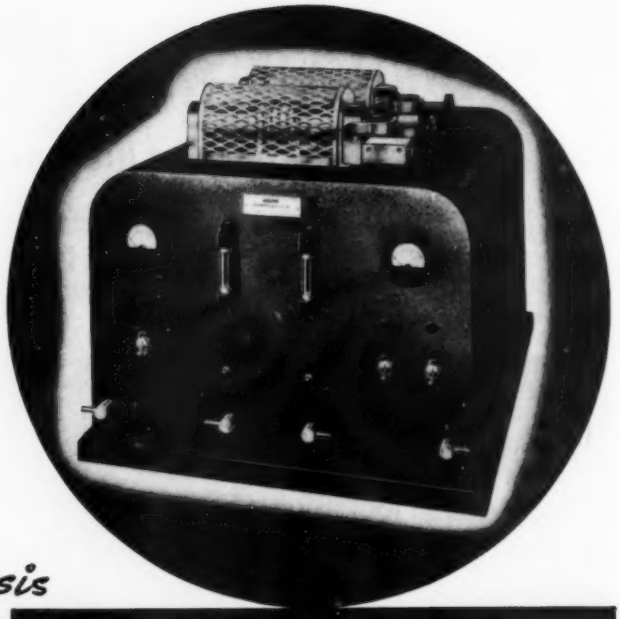
COMBUSTRON MODEL 120

by **BURRELL**



For carbon analysis in ferrous metals

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TWO SEPARATE CIRCUITS PROVIDE TWO UNITS IN ONE

Once again—Burrell has blazed a trail to greater value and service. With a Combustron, Model 120, users get two separate high frequency induction heaters built into one compact laboratory instrument. Operation of one circuit does not affect operation of the other in any way. Thus users get dual value—for heavy production or standby convenience.

Loading is horizontal for greatest flexibility. Combustion boats may be used for a great variety of samples ranging from coarse to fine meshes and low to high carbon content including alloy steel, cast iron and stainless steel. And—for analysis of low carbon steels, each Burrell combustion boat will take up to a full factor weight of coarse drillings.

Either Combustron model—two tube or one tube—provides rapid and accurate analysis of carbons-by-combustion.

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Two Tubes—Two Circuits
115 Volt—60 Cycle
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115 Volt—60 Cycle
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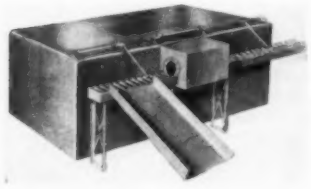
LABORATORY APPARATUS FOR SCIENTISTS EVERYWHERE

Engineering Digest

OF NEW PRODUCTS

INDUCTION HEATING: The Loftus Engineering Corp. has developed a new 60-cycle induction furnace for the heating of nonferrous metals and some applications of steel. The furnace provides uniform heating and



the patented process involves a transformer which converts balanced three-phase power into two-phase operation. Two closely interlaced coils, leading off this two-phase line, surround the billet and provide the uniformity and penetration of single-phase heating. Large eddy currents are caused to flow in the billet to be heated, insuring fast, clean, uniform heating for forging, extrusion and rolling.

For further information circle No. 554 on literature request card on p. 32B

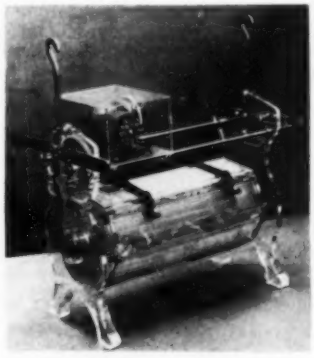
METAL CLEANING: Magnus Chemical Co., Inc., has announced the new Aja-Lif parts cleaning machine. This equipment is air-powered, not air-agitated. With single lever operation, a flick of the operating lever brings the platform to the top of the tank, out of the liquid for inspection, loading and unloading the work, thus avoiding groping in the scalding and dirty cleaning solution trying to locate the parts to be removed. A second flick of the lever lowers the platform to the bottom of the tank where the work is immediately, automatically and vigorously agitated up and down in the solution, "shearing" the dirt from the parts in an unbelievably short time and eliminating hand scrubbing or brushing. The Aja-Lif cleaning machines are available in three sizes. Heating is by gas, steam or electricity.

For further information circle No. 555 on literature request card on p. 32B

TRANSFORMER WELDER: Air Reduction Sales Co. has announced a new 200-amp. transformer welder. The Airco Model MCM is designed for general maintenance and production welding. It has a full 200-amp., 50% duty cycle, NEMA rating. Four variations are available — 220-volt or a 220/440/550-volt unit, each with or without power factor correction. Two open circuit voltages are provided — 80 volts on the low range and 55 volts on the high range. This combines easy arc starting with a lower Kva. demand load and primary ampere current. Safe, dependable operation is assured by complete, up-to-the-minute insulation throughout. The easy-to-read current indicator affords quick adjustment of welding current. Maintenance cost is low because there are no moving parts.

For further information circle No. 556 on literature request card on p. 32B

PORTABLE PLATING BARREL: A new development of the Hanson-Van Winkle-Munning Co. is the Mercil portable-type plating apparatus with Plexiglas cylinder. This equipment, which is made with cylinders 6 in. in



diameter by 12 in. long and 8 in. in diameter by 18 in. long, will enable the user to process small parts efficiently. The entire unit is light in weight and can be easily handled. A rheostat is included so that the cylinder can be operated at various speeds. Cylinder legs and gears are of Plexiglas; the motor is 1/15 hp., suitable for operation on 110 or 220-volt, single-phase, 60-cycle power circuit. It can be used in either acid or alkaline solutions, providing the temperature of the bath does not exceed 185° F.

For further information circle No. 557 on literature request card on p. 32B

WELDING ELECTRODE: A new type of resistance welding electrode, marketed under the name Kaptrode, is announced by Weiger Weed & Co., division of Fansteel Metallurgical Corp. The electrode consists of an ex-

pendable cap which fits into a semi-permanent adapter shank. This in turn fits into any standard Morse taper-type electrode holder. Depending upon the length of the adapter shank, copper savings up to 75% are possible. Kaptrode electrodes are made in six nose styles (pointed, dome, flat, offset, truncated cone and radius face), in three RWMA alloys (Class 1, 2 and 3), and two Morse taper sizes (No. 1 and 2). With the proper shank length, it is possible to duplicate standard electrode lengths and use Kaptrode electrodes without changing established machine set-ups.

For further information circle No. 558 on literature request card on p. 32B

SCANNING INSTRUMENT: An electronic scanning system designed to monitor, automatically and continuously, up to 270 separate processing temperature points has been developed by Brown Instruments Div., Minneapolis-Honeywell Regulator Co. The new system records only those temperatures which deviate beyond a preset limit. It includes an audible alarm that permits immediate correction of excess temperatures, and replaces the cost and use of several instruments and time-taking logging operations and maintenance.

For further information circle No. 559 on literature request card on p. 32B

CONSTANT TEMPERATURE BATH: Precise control of water bath temperatures, in an order never before attained, is provided by the new Fisher Isotemp bath. The constancy of bath temperature claimed for the new bath is ± 0.005° C. over its entire range of about −5 to +107° C. Actual tests have produced variations as small as 0.002° over a long period of time. A complete design change from conventional water bath employs

MAGNESIUM

and the

SALEABILITY

of your product

Competition is a great American institution to the consumer—but at times it plays havoc with your sales department. The simple solution, of course, is "build a better mousetrap." And it may be just that simple when you use magnesium.

The many inherent advantages of this ultra-light metal become sales advantages for you. In many cases great savings in weight through increased use of magnesium has made possible numerous design improvements and the addition of extra sales features. Also, consider the psychological effect a lightweight product has over a heavier one—even when the weight is of no functional importance! With but a few obvious exceptions, anything that has to be moved or lifted will gain consumer acceptance quicker, if it's lighter. Many of the country's more progressive manufacturers have already found that magnesium permits better design, better performance . . . hence, a more saleable product.

So if you are making, or contemplate making anything in which light weight is important—or if you are just bent on beating competition—plan with magnesium. It has already made many products better, more versatile, easier to handle, more profitable to sell . . . it may improve yours.

This Little "Pig" Was Drafted . . .

Today, magnesium like many other metals, is a tremendously important part of our defense effort, particularly where light weight is a specification in design. As a result, the supply for commercial uses is often limited. But "tomorrow," magnesium promises new horizons in the field of metal supply. *The seas, at our own shores, can provide 100 million tons per year for a million years without significantly reducing the supply!*

THE DOW CHEMICAL COMPANY

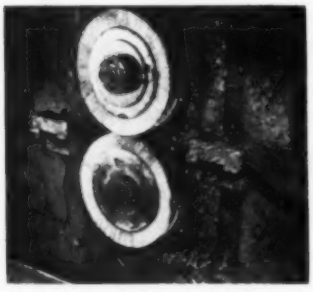
Magnesium Department • Midland, Michigan

New York • Boston • Philadelphia • Atlanta • Cleveland • Detroit • Chicago • St. Louis • Houston
San Francisco • Los Angeles • Seattle • Dow Chemical of Canada, Limited, Toronto, Canada

an electronic circuit to control 400-watt and 800-watt heaters. Also, the heating elements, stirrer and controls are contained in a central column with all connections made through the bottom of the glass bath — thus providing an unobstructed top surface for inserting samples. Stirring is effected by a 1150-r.p.m. motor and propellers so that the entire 10-gal. water (or light mineral oil) content is constantly in motion.

For further information circle No. 560 on literature request card on p. 32B

POWER BRUSHES: New power brushes, manufactured by the Osborn Manufacturing Co., remove heat treating scale and prepare strip surface for name etching. Cutting tool strip



is pulled through the brushes at 50 ft. per min. The brushes rotate at 3450 r.p.m. As they become grooved from wear, they are reversed. Bevel gears move the brushes up or down as required. In this production-line application, a two-station machine has replaced equipment having six brushing heads.

For further information circle No. 561 on literature request card on p. 32B

WELDING: Fillerweld, a new product designed to speed alloy-metal welding on applications where filler-metal must be added, has been announced by General Electric's welding department. Used with gas-shielded arc welders, Fillerweld allows the operator to control the continuous flow of filler-metal automatically by means of a finger switch mounted on the torch. According to G-E engineers, the new welding attachment allows the operator to start or stop the flow of filler-metal without breaking the arc, resulting in a smoother, faster weld. Fillerweld consists of two main elements — the torch or "gun" and a mechanical power unit. The gun is basically a manual water-cooled inert-arc tungsten holder to which has been added a control switch and a gear assembly for pulling the filler-metal from the spool to the arc through the gun. Rated at 250 amp., the gun accommodates tungsten from 0.040 to $\frac{1}{8}$ in. in diameter and up to 7 in. long. The mechanical power unit consists of a motor which provides the power for drawing the filler-metal, a motor control unit, and a spool which holds the filler wire. The unit is mounted on a portable platform and can be moved easily from job to job.

To operate the new equipment, the operator merely presets the desired filler wire speed by means of a rheostat located on top of the control unit. He then takes the gun just as if it were a normal inert-arc torch and strikes the arc. As soon as a molten pool has been established on the base metal, the operator pulls the trigger on the gun and the wire feeds into the arc. To stop the wire feed at any time, even during welding, the operator has only to release the trigger. Another advantage of the new Fillerweld equipment, the engineers said, is the ease with which operators can be trained to use it. In demonstrations, experienced arc or gas welders have learned to use the new welder successfully after only a few minutes of experimentation.

The new process can be applied to best advantage on stock less than $\frac{1}{8}$ in. thick. However, where speed is not of paramount consideration, Fillerweld will produce a high quality weld on thicker material. The equipment

can be used with a G-E Type WP inert-arc welding transformer for welding aluminum, magnesium, or beryllium copper; or with a G-E Type WD-4150 or WD-4200 for welding stainless steel, copper, inconel, steel, and other weldable alloys. Either argon or helium can be used with the equipment.

For further information circle No. 562 on literature request card on p. 32B

ELECTRON DRILL: The M-7 Tapmaster, for rapid removal of broken taps, drills, reamers and studs, is the most recent development of the Elox Corp. of Michigan, originator of electron drills for production cutting of hardened metals. In removing a

broken tap or drill, an electrode about half the diameter of the broken tool is used, and the head lowered so the electrode is centered about ¼ in. above the tap. As the head is fed downward, in the same manner as a drill press, a series of electric arcs cuts down between the core and threads of the tap without damage to the threads. A coolant pumped through the hollow electrode washes away particles of metal.

For further information circle No. 563 on literature request card on p. 32B

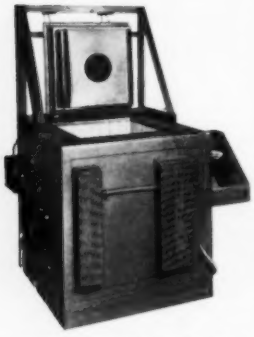
HARD FACING ROD: Wall Colmonoy Corp. announces a new hard facing rod, Wallex, for abrasion resistance with good impact and corrosion resisting properties. Containing chromium, molybdenum, manganese and silicon, this rod has a hardness of Rockwell C-57 to 61. Typical applications include conveyor parts, pipe line elbows, coke ash plows, clam shell bucket lips, drag chain idlers, grinding rings, coal crusher teeth and rolling mill guides.

For further information circle No. 564 on literature request card on p. 32B

FINISHING WELDED SEAMS: Sunstrand's straight-line action air sander speeds finishing of welded seams. Because of its straight-line action, the sander leaves no swirls or pressure marks, a feature of primary importance in all work where an extra-smooth surface is required. Grinder marks are quickly removed and the metal is properly conditioned

The *New* HUPPERT VERTICAL ELECTRIC FURNACE

The latest addition to a broad line



Send for complete information and sizes on this new Vertical Furnace and also the standard line of Huppert furnaces and ovens.

Here's a vertical electrical furnace that can be adapted to unlimited general and industrial uses such as steel hardening, tempering, drying and firing of ceramics. One of several versions of this rugged furnace features an inside fan assembly for equalized temperatures up to 1250° F. Another version provides a maximum temperature of 2000° F. without fan.

Sturdy Kanthal heating elements, mounted in refractory plates, are located on the four sides of the heat chamber. Multi-insulation assures maximum heat retention at all times. Power relays, fused switch box and all interconnections are factory installed —unit ready to operate upon delivery.

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CASTING

This is the modern tool for the manufacture of small intricate parts...vital for quick production on defense orders and essential for functional design.

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Over 200 tube sizes from .898″ O.D. to 8.250″ O.D. Bar sizes from .171″ round to 7.5″ round. Also Ring Forgings.

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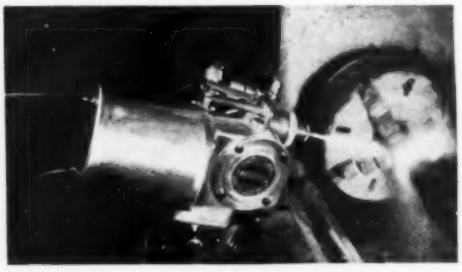


Rebuild Worn Parts *by Metallizing*

Save time, money and critical parts by Metallizing with new Mogulectric Gun. Adds metal to metal with fine atomization for perfect bond. Simplified, easy to use, engineered to give trouble-free service.

Also ideal for spraying corrosion-resistant metal coatings and for production work.

If you already have metallizing equipment, why not consider a trade-in now for the new Mogulectric Gun.

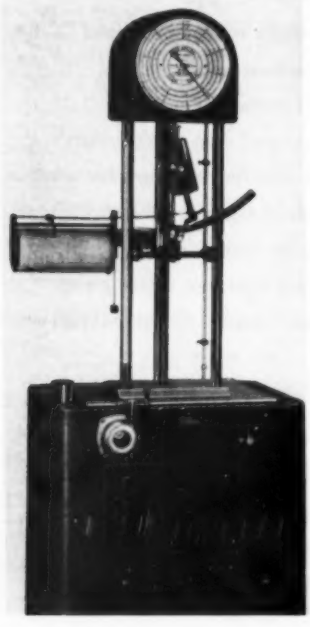
Write for new booklet containing complete information on equipment as well as production and maintenance applications.

METALLIZING COMPANY OF AMERICA

3520 W. Carroll Avenue • Chicago 24, Ill.

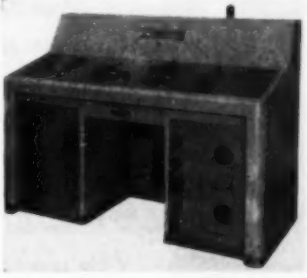
for painting. A good example of this is the graining and blending-in of a welded seam in stainless steel products. In the aircraft industry sanders are extensively used to remove burrs over rivet holes and scratches.
For further information circle No. 565 on literature request card on p. 32B

TESTING MACHINE: W. C. Dillon & Co., Inc., announces an improved Universal Tester. It contains the following improvements: Zero to 300-lb. scale, improved motor drive assuring full torque up to 300 lb.,



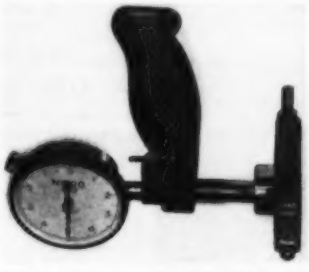
solid shaft connecting speed control to motor transmission, and a speed control dial mounted on top of the tester base. It will test springs, wire, and other materials that fall within its 300-lb. range.
For further information circle No. 566 on literature request card on p. 32B

MAGNETIC TESTING DESK: A new d-c magnetic testing desk, containing all of the major components and auxiliary equipment necessary for making routine d-c magnetization and hysteresis tests and simple flux measurements, has been announced by the General Electric Co. The desk is designed for use with various permeameters and magnetic devices which make possible the testing of nearly all types of magnetic materials. These include soft magnetic sheet, strip materials, and high-coercive-force compositions such as alnico, silmanal



and cobalt-platinum magnet alloys. With a base of 5 ft. 4 in. by 2 ft. 6 in. and a height of 4 ft. the new testing desk weighs 600 lb. Its normal range of current control, depending on the auxiliary equipment, extends from zero to 40 amp. It operates on any moderately steady 125-volt d-c supply and 115 volts, 60 cycles a-c.
For further information circle No. 567 on literature request card on p. 32B

BORE GAGE: Nilco pistol-type bore gage, a product of Nilsson Gage Co., was designed to check bores on the machine by the operator where space is limited and it is impractical to use a standard length bore gage. Additional features on this re-designed gage include positioning of the indica-



tor to the proper angle so that it will face the operator at all times and the adjusting of the handle to the proper checking depth. Gages are made in five ranges.
For further information circle No. 568 on literature request card on p. 32B

"Look How Rudolph's Output Has Increased Since They Changed to the Right Cutting Fluid"

THE BEST MACHINE and the finest operator cannot do the best work without the *right* cutting fluid.

Stuart combines theory and practice to give you the right cutting fluid for the job. Here is an example:

In a large gear department, cutting fluid tests were run on Gleason Revacycles cutting 8620 gear stock, 179 Brinnel hardness.

	"X" Oil	Stuart's SPEEDKUT "A"
Gears Per Tool Grind	1200	3200
Stock Removal to Recondition Cutters	.009"	.0035"
Price of Cutting Oil	33c/gal.	35c/gal.

There's a story! More production because of less downtime. Longer cutter life because of fewer grinds and less stock removal per grind. A lower *actual cost* for the cutting fluid.

You can get help like this from a Stuart Representative. Ask to have him call.

Are you receiving Stuart's Shop Notebook regularly?
Write, wire or phone

GET MORE PRODUCTION
Use The Right Cutting Fluid

STUART SERVICE
Goes with every Barrel
Offices in Principal Industrial Centers

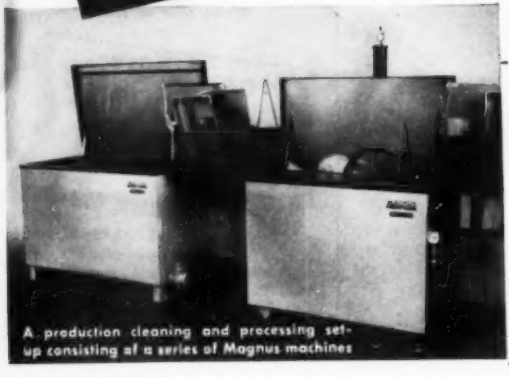
D.A. Stuart Oil CO.
2743 S. Troy St., Chicago 23, Illinois

STOP BEFORE YOU BUY ANY CLEANING EQUIPMENT . . . Get the facts on the Amazing Magnus AJA-LIF Cleaning Method

FOR THESE OPERATIONS — **Alkaline or Solvent Cleaning • Removal of Buffing Compounds, Tripoli, Rouge • Cleaning before Painting • Screw Machine Chip Removal • Cleaning after Heat Treating • Quenching • Maintenance Shop Cleaning**

Platform with work at loading level

Platform with work being lowered (note new batch of parts coming in)



A production cleaning and processing set-up consisting of a series of Magnus machines

CHECK THESE MAGNUS AJA-LIF FEATURES AGAINST ANY OTHER CLEANING EQUIPMENT

- ✓ Superior cleaning with agitation
- ✓ Saves labor—one man operation
- ✓ Fits any production line
- ✓ On-the-Spot cleaning in any department
- ✓ Uses low-cost *available* cleaners
- ✓ Eliminates fire hazard
- ✓ No gears—no electric motors—no sprays
- ✓ Eliminates worker fatigue
- ✓ Expands to include other operations
- ✓ Saves valuable floor space
- ✓ Low initial cost—low upkeep
- ✓ Eliminates overhead conveyors; hoists
- ✓ No groping in cleaning solution for work
- ✓ Loads—unloads at top of machine
- ✓ Flexible set-up for intermittent cleaning
- ✓ One lever lowers, agitates, raises parts
- ✓ Turbulent action "shears" dirt, chips from parts

• • •

IT COSTS YOU NOTHING to investigate this new Aja-Lif equipment that may be the answer to your production problems

USE THIS COUPON TODAY

MAGNUS CHEMICAL CO., INC. — EQUIPMENT DIV.
96 South Avenue, Garwood, N. J.

Send data on Magnus Aja-Lif Method for cleaning .....

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COMPANY_____

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CITY_____ ZONE____ STATE_____

BY_____ TITLE_____

Please attach to your Letterhead

What's New

IN MANUFACTURERS' LITERATURE

569. Alloy Steels
Booklet on the selection of the proper alloy steel grades for each manufacturers' needs. Write for "Wheelock, Lovejoy Data Book". *Wheelock, Lovejoy & Co.*

570. Alloys
"Thermalloy 30" gives property data for 21% Cr, 9% Ni heat resistant alloy. *Electro-Alloys Div.*

571. Aluminum Castings
New Fact-File folder describes aluminum die castings, aluminum permanent mold castings and zinc die castings. *Monarch Aluminum Mfg. Co.*

572. Anti-Carburizing Paint
Descriptive literature is available on paint which prevents carburizing or hardening of certain spots on steel parts. *Case Hardening Service Co.*

573. Arc Welding
Heliwelding, Airco's inert, gas-shielded arc-welding process for all-position welding of aluminum, magnesium, stainless steel, brass and copper, is fully described in ADC-709, Catalog 9. *Air Reduction Sales Co.*

574. Arc-Welding Electrodes
19-page booklet, by three welding specialists, summarizes results obtained with commercially available alloy steel rods in welding of high-strength ferritic steels. *International Nickel Co., Inc.*

575. Atmosphere Generators
Bulletin on atmosphere generator for small-capacity furnaces. Flow diagram, specifications, applications. *Hevi Duty Electric Co.*

576. Bending
32-page illustrated manual describes procedures for bending a wide variety of shapes from tubing, angles, channels, extrusions and other solid forms. *O'Neil Irwin Mfg. Co.*

577. Blast Cleaning
Bulletin 32-B contains photographs and complete descriptions of AG blast cleaning cabinets for all types of industrial applications. *Ruemelin Mfg. Co.*

578. Bottom Boards, Magnesium
Complete information and price schedule on magnesium bottom boards for maintaining high quality castings and mold stability. Available from stock in 74 standard sizes. *Christiansen Corp.*

579. Brazing
Ajax salt bath brazing process is fully described in bulletin 124. Shows how it is possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies by this brazing method. *Ajax Electric Co.*

580. Brinell
Bench model Brinell hardness tester (Model J) is illustrated and described in bulletin. *Steel City Testing Machines, Inc.*

581. Bronze Alloys
New folder giving tables of properties (hardness, tensile, fabrication, physical) as well as uses and forms and other data on Chase phosphor bronzes. *Chase Brass & Copper Co.*

582. Carbon Determinators
Leco CD-10, conductometric carbon determinator, described in 4-page folder. *Laboratory Equipment Corp.*

583. Castings, Heat Resistant
4-page bulletin describes heat resistant castings produced in designs for a wide variety of applications, including conveyors, roller hearths, trays, and radiation tube assemblies. *Standard Alloy Co.*

584. Castings, Nonferrous
Booklet available on sand and centrifugal castings. *American Non-Gran Bronze Co.*

585. Cleaning
A descriptive product data sheet tells of 313-A, a special acid phosphate cleaner developed for preparation of metal surfaces for painting, lacquering or japanning. *E. F. Houghton & Co.*

586. Cleaning
Bulletin 213 gives full details, specifications and actual performance on faster blast cleaning with Rotoblast barrels. *Pangborn Corp.*

587. Cleaning
Information on new cleaning process that uses emulsion cleaners, based on petroleum and addition agent 230. This two-phase bath provides unique cleaning in conjunction with a thin displacement film that removes foreign particles. *Northwest Chemical Co.*

588. Cleaning
Bulletins are available on Virgo descaling salt and Virgo molten cleaners. Learn what they are, how they work, their advantages and how they fit into your operations. *Hooker Electrochemical Co.*

589. Cleaning
Data on Aja-Lif equipment for removal of buffing compounds, chip removal, quenching and other cleaning operations. *Magnus Chemical Co.*

590. Cleaning
Bulletin 74-15 gives data on all-electric steam detergent cleaning. Pressures to 200 psi. *Livingstone Engineering Co.*

591. Cleaning Equipment
Bulletin G18 describes special features of cleaning, drying and pickling equipment. *Metalwash Machinery Corp.*

592. Coatings
Information available on Bonderite, nonmetallic coating which is resistant to corrosion and a good paint base. *Parker Rust Proof Co.*

593. Coatings and Packaging
New 43-page working data file provides valuable guide to better preservation and packaging with three sections on coatings, melting equipment and methods and processing procedures for "hot dip" packaging. *Seal-Peel, Inc.*

594. Combustion Equipment
Bulletin shows complete line of burners, mixers, valves and blowers used in gas combustion for industrial purposes. *Eclipse Fuel Engineering Co.*

595. Contact Wheels
New type of rubber contact wheel which adds 50% more life to abrasive belts is described in folder. *Carborundum Co.*

596. Controls
Catalog No. 51-1 gives full data on controls for annealing furnaces including ElectroniK potentiometer controls, Air-O-Line pressure controls, pyrometer & switch for spot temperature checks and flow meter for fuel cost accounting. *Minneapolis-Honeywell Regulator Co.*

597. Copper Alloys
40-page booklet contains Federal, Navy, A.S.T.M., S.A.E. and A.M.S. specifications for ingots and castings. Data section contains constitutional diagrams and other reference material. *Barth Smelting Corp.*

598. Copper Alloys
New 4-page folder lists 65 commonly used brass and copper alloys, along with their composition, properties, forms and typical uses. *Bridgeport Brass Co.*

599. Copper and Copper Alloys
New 24-page booklet B-36 discusses corrosive attack on copper and copper alloys. Includes tabulation for relative corrosion resistance of principal types of copper-base alloys. *American Brass Co.*

600. Cut-Wire Shot
Economies and characteristics of cleaning and peening with cut-wire shot are described in a 4-page folder. *Cleveland Metal Abrasive Co.*

601. Cutting Oils
Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service Oil Co.*

602. Cutting Oils
New bulletin on "Gulf Electro Cutting Oil" which contains larger percentage of active sulphur ingredient, recommended for toughest machining jobs. *Gulf Oil Corp.*

Sperry

REFLECTOSCOPE MEANS "ON THE JOB" *Ultrasonic* INSPECTION OF METALS AT LOW COST IT'S *Portable*, TOO

Reflectoscope non-destructive testing locates internal defects accurately—instantaneously. Penetrates up to 25 feet. Tests raw stock, semi-finished and finished products and detects fatigue fractures. Available for rent, for lease and for sale. Write for descriptive bulletin 50-105.

95 lbs. 14¼" x 18¼" x 23½"

TESTS DEPTH UP TO 25 FEET

THIS BOOKLET CAN SAVE YOU MONEY AND SPEED UP PRODUCTION. WRITE TODAY.

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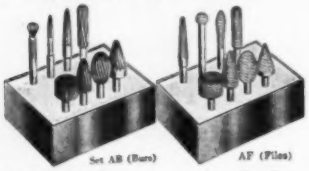
MARTINDALE

ROTARY BURS AND FILES

Made of high-speed steel. Produced in our own factory where uniform hardness is assured by heat-treating in electric furnaces on which the temperature is closely controlled by electric eyes.



Sets AB & AF	Per Set
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The above sets, with ¼" diameter shanks, are composed of the 8 most popular sizes for general use.

Over 200 sizes and shapes (total over 75,000 pieces) are carried in stock for immediate shipment.

METAL-WORKING SAWS

Made of 18-4-1 High Speed Steel in 4 types for ferrous and nonferrous metals. Diameters range from 1¾" to 4".

"MOTOR-FLEX" GRINDERS

These high-quality, portable flexible-shaft tools are made in 7 types for operation on bench, floor, or overhead.

VISIT OUR BOOTH AT THE PLANT MAINTENANCE SHOW
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Write for 64-page Catalog No. 28 covering above and many other products for maintenance, safety, and production.

MARTINDALE ELECTRIC CO.
1372 Hird Avenue, Cleveland 7, Ohio

603. Cutting Oils

Send for your copy of Stuart's Shop Notebook, giving important facts on right cutting fluid for any machining operation. *D. A. Stuart Oil Co.*

604. Degreaser

12-page illustrated bulletin describing operation of degreasing equipment and specific applications of vapor degreasers, both tank-type and conveyorized. *Phillips Mfg. Co.*

605. Die Designs

Attractive 32-page booklet describes design of dies for upsetting forging machines. *Ajax Mfg. Co.*

606. Die Springs

Illustrated price list of several hundred stock sizes of die springs, with separate listings of accessories. *The Die Supply Co.*

607. Die Steels

Booklet, "Die Steels for Hot Work", helps in selection of best grade for your particular job. *Vanadium-Alloys Steel Co.*

608. Dry Cooler

Bulletin DC-50 illustrates complete line of Dri-Coolers in a wide range of capacities and designs for specific cooling jobs. *Marley Co.*

609. Electrodes

New 12-page booklet, "The ABC's of Welding High Tensile Steels", guides buyers and users of low-alloy, low-hydrogen electrodes. *Arcos Corp.*

610. Electron Microscope

The new table model RCA electron microscope is described and illustrated in a 12-page booklet. *Radio Corp. of America.*

611. Fabrication

Illustrated folder describes facilities for mass production of defense prime contract and subcontract work. *Charles T. Brandt, Inc.*

612. Fasteners

Complete file contains illustrations and engineering descriptions of fasteners and fittings for resistance welding, adjusting screws, adjustable feet and other products. *Ohio Nut & Bolt Co.*

613. Finishes

New brochure gives full details on Black Magic Type A, blackening process for iron and steel. *Mitchell-Bradford Chemical Co.*

614. Forging

New booklet, "Improvement of Metals by Forging", gives full details on forgings with controlled directional properties for durability, economy, strength and machinability. *Steel Improvement & Forge Co.*

615. Forgings

New catalog 51 contains 30 pages covering such topics as type of forgings; where and how to use forgings; turnbuckle dimensions, strengths and related data. Well illustrated with tables and drawings. *Merrill Bros. Co.*

616. Forging Steel

Bulletin 31, "Chemical Composition of Alloy Steels", furnishes helpful information on stainless forging problems and includes specific data on chemical composition of alloy steels. *Timken Roller Bearing Co.*

617. Forming

Function, economics, scope and mechanics of cold roll forming are discussed in 86-page illustrated book. *Yoder Co.*

618. Forming

Special bulletin of metal spinning, stamping and fabricating facilities. *C. A. Dahlin Co.*

619. Fuel-Air Ratio Control

Metered control of fuel-air ratio in single and dual-fuel metallurgical furnaces is discussed in Instrumentation Data Sheet 4.3-4. *Minneapolis-Honeywell Regulator Co.*

620. Furnace, Atmosphere

Bulletin F-1 gives full description of versatile, controlled-atmosphere furnace for all steels from high carbon to high speed in range 1200–2800° F. *Delaware Tool Steel Corp.*

621. Furnace Controls

Instruments and controls for heat treating furnaces are described in Bulletin 49-750. *Hays Corp.*

622. Furnaces

Illustrated bulletin available with complete description of new controlled atmosphere furnace. *Industrial Heating Equipment Co.*

623. Furnaces

Full information furnished on new gas-atmosphere high-production furnace for handling bright annealing of wire, strip and bar stock of copper and nonferrous copper alloys. *Holcroft & Co.*

624. Furnaces

New illustrated bulletin SC-152 presents heat treating furnaces for the aircraft industry. Conveniently divided into sections on basic aircraft components. *Surface Combustion Corp.*

625. Furnaces

High temperature furnaces for temperatures up to 2000° F. are described in leaflet. *Carl-Mayer Corp.*

626. Furnaces

Bulletin 346 describes new electric muffle furnaces designed to heat materials in an oxidizing atmosphere for many research, toolroom and production operations. *Harper Electric Furnace Corp.*

627. Furnaces

Catalog 110 features new heat treating furnaces and atmosphere charts. *C. I. Hayes, Inc.*

628. Furnaces

Complete "Buzzer" catalog available describing Buzzer high-speed gas furnaces designed primarily for heat treating high carbon and alloy steels and also atmospheric pot hardening furnaces for salt, cyanide and lead hardening. *Charles A. Hones, Inc.*

629. Furnaces

6-page folder describes 18 typical installations of gas-fired and electric furnaces of various types, complete with specially designed equipment for bright annealing, scale-free hardening, carbon restoration, carburizing and production heat treatment. *Electric Furnace Co.*

630. Furnaces

Ask for catalog A-6 for descriptive matter on tool hardening equipment Model YP (vertical type) and Model 2Y. *Sentry Co.*

631. Furnaces, Melting

Catalog on Heroult gantry-type electric melting furnace with patented roof-ring to assure speedy and simple bricking and eliminate skew shapes. *American Bridge Co.*

632. Gas Analysis

Theory of gas analysis, procedures involved in various analyses and instructions on maintaining and operating equipment are discussed in 60-page manual. *Fisher Scientific Co.*

633. Gas Cutting Machine

New catalog available on Arco No. 50 Travograph gas cutting machine, equipped with three distinctly different tracing devices — manual, magnetic, or full-automatic Electronic Bloodhound to cut most intricate shapes from only an outline drawing. *Air Reduction Sales Co.*

634. Gas Producers

Bulletin 1-10 supplies technical information on inert gas generators and data on reducing inert gas costs. *C. M. Kemp Mfg. Co.*

635. Gas Sampling

16-page bulletin describing oxygen recorder and applications in sampling and analysis of atmospheres. Instrument based on paramagnetic properties of oxygen. *The Hays Corp.*

636. Gauges

Bulletin BG-MP describes highly accurate beta radiation gauge used for thickness measurements. One model measures thickness of material accessible from one side only. *Tracerlab, Inc.*

637. Hardness Tester

Bulletin F-1689-1 tells of the Impressor, hardness tester for aluminum, copper, brass, bronze and plastics. *Barber-Colman Co.*

638. Hardness Testers

Bulletin DH-114 contains full information on Tukon hardness testers for use in research and industrial testing of metallic and nonmetallic materials. Also included is bulletin DH-7, outlining experiences in various fields. *Wilson Mechanical Instrument Co.*

639. Hardness Testers, Portable

Illustrated circular describing the Ames portable hardness tester in sizes for work 1 inch to 6 inches round and flat. *Ames Precision Machine Works.*

640. Heat Treating

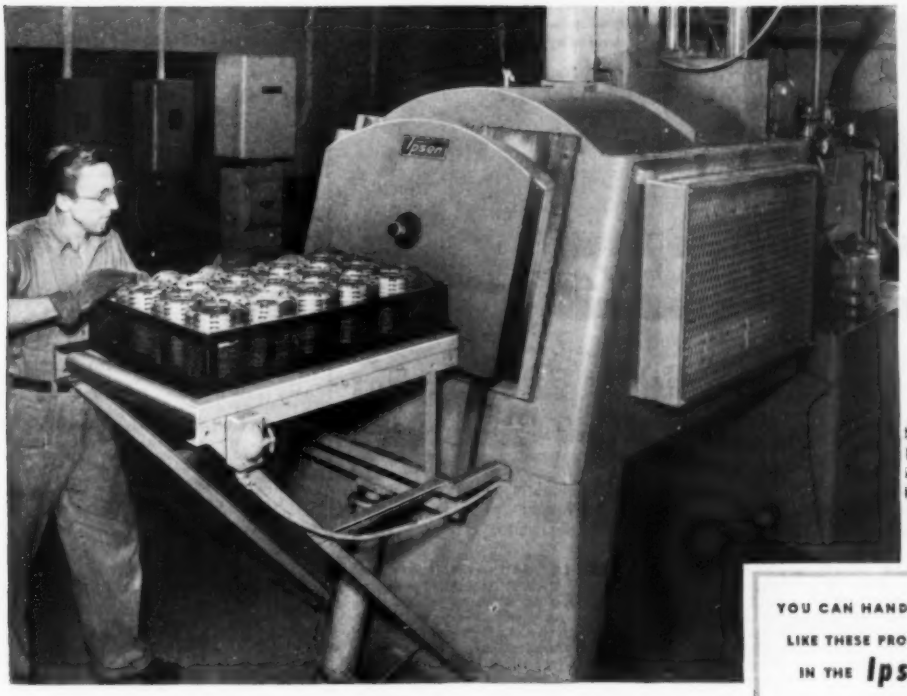
Barrett standard anhydrous ammonia is available in 150, 100 and 50-pound cylinders in conveniently located stock points. Send for literature. *Barrett Div., Allied Chemical & Dye Corp.*

641. Heat Treating

Bulletin HD1147 describes new combination heating unit for tool rooms and small manufacturers. *Hevi Duty Electric Co.*

642. Heat Treating

Ipsenlab periodic sheets show case histories on bright hardening, annealing and carburizing. *Ipsen Industries, Inc.*



See this Equipment at METAL SHOW Booth F-360

4 Important Production Advantages with New *Ipsen* HEAT TREATING UNIT

Designed for carbonitriding, carburizing, hardening, brazing, and martempering, new Ipsen Automatic Production-Type Heat Treating Units offer outstanding production and metallurgical advantages in processing a wide variety of workpieces. The features outlined below are essentially the reasons why more than 75 plants in the past two years have selected, and are today using, Ipsen Equipment to speed heat-treating operations and cut costs:

1 AUTOMATIC OPERATION — from heat through quench (or cooling), reduces work handling, eliminates guess work, assures uniform results on a production basis.

2 BRIGHT, CLEAN, SCALE-FREE WORK — with sealed atmosphere control. Eliminates cleaning and processing operations prior to and following heat-treatment, effects substantial savings in production costs.

3 CRACKING AND DISTORTION REDUCED — by controlled quenching with two-speed oil circulation and automatic temperature regulation.

4 FAST, EFFICIENT PROCESSING — versatile and easy to handle variety of work, no idle time for change-overs, no danger of burring or marring, quick burn-off. Saves time, increases output.

YOU CAN HANDLE JOBS LIKE THESE PROFITABLY IN THE *Ipsen*

Pliar Segment — C1060 Clean hardened. Finish Grind eliminated.

Gear — C1020 — carbonitrided. Cleaning before plating eliminated.

Valve — C1020 welded to C1045 — stress relieved and hardened. Retapping operation eliminated.

Release Lever — carbonitrided 600 per hour. Blasting eliminated.

Heavy Bull Gear Pinions SAE 8630 — carburized 39 per hour.

THE AUTOMATIC *Ipsen* HEAT TREATING UNIT

***Write* TODAY FOR MORE FACTS** . . . Ask for free bulletins and find out how Ipsen Heat-Treating Units and methods can be applied to your work. If you wish, samples or production lots of your work will be run, proper procedures established, and results predetermined without obligation.

IPSEN INDUSTRIES, INC. 715 South Main Street, Rockford, Illinois

Production Units for CARBONITRIDING · CARBURIZING · HARDENING · BRAZING · MARTEMPERING

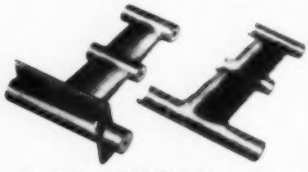
A jet turbine stator section fabricated of cobalt base alloy and AISI 310 stainless steel, brazed with NICROBRAZ.

NICROBRAZ

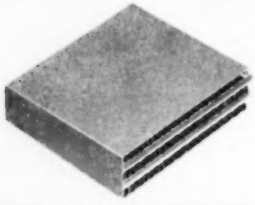
New corrosion resistant alloy brazes stainless steel for 2000° F. service

COLMONOY NICROBRAZ is a heat and corrosion resistant nickel-chrome alloy, developed primarily for brazing stainless steels and special alloys. It has these highly desirable qualities:

NICROBRAZ resists high heat. A NICROBRAZ joint in a stainless steel assembly has a tensile strength equal to that of the parent metal while the assembly is operating at 2000° F. This quality ranks NICROBRAZ above any other known material for brazing parts for service in the high temperatures of modern aeronautical power plants.



Previously cast, this fuel injection nozzle support assembly is now stamped (right) of S 590 stainless alloy and then brazed (left) with NICROBRAZ.



Heat exchanger is made up of five corrugated and six flat sheets of 316 stainless steel, .010" thick. Brazed with NICROBRAZ in one operation.

Mercury bulb and tube assembly. Tube is .032" stainless steel with .006" I.D. hole. Five joints brazed in one operation with NICROBRAZ.

NICROBRAZ resists oxidation and corrosion. It is extremely resistant to the action of most chemicals and retains its physical properties under oxidizing conditions. Previously, for lack of a corrosion resistant brazing alloy, many stainless steel assemblies have been machined from the solid, or welded or assembled by mechanical means. With NICROBRAZ they'll be made more easily and at less cost. NICROBRAZ will change design thinking in many industries, such as: *aeronautical, automotive, food, dairy, pharmaceutical, nuclear energy, control instruments, chemical, and oil refining*

NICROBRAZ is available as a powder or in strip and shim stock. It flows readily at 2100° F. in a pure dry hydrogen atmosphere, and will penetrate a contact joint by capillary action. When brazing stainless steels, a stable new alloy is formed by the NICROBRAZ alloying with the parent metal. Its ductility, strength, and corrosion resistance is then about the same as that of the parent metal and it has a much higher melting point then the original NICROBRAZ.

Wall Colmonoy Corporation maintains a plant at Detroit with the equipment necessary for the development and production of stainless steel joining operations utilizing NICROBRAZ. Bright annealing, bright hardening, complete heat treating, and the brazing of stainless steel and other alloys can also be processed in our plant.

For more information contact Wall Colmonoy Corporation, 19345 John R Street, Detroit 3, Michigan.

Branches; Long Island City, Buffalo, Chicago, Houston, Los Angeles, Montreal.

WALL COLMONOY
CORPORATION
HARD FACING ALLOYS
19345 JOHN R STREET DETROIT 3, MICHIGAN

643. Heat Treating

Handy, vestpocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. *Sunbeam Industrial Furnace Div.*

644. Heat Treating

"Surface Hardening of Stainless Steel", illustrated booklet, is available on request. *Lindberg Steel Treating Co.*

645. Heat Treating Controls

Bulletin PB1237 tells of free-vane electronic pyrometer controllers for automatic control of furnaces, ovens and salt pots. *Bristol Co.*

646. Heat Treating Conveyors

Conveyorized heat treating is shown to boost production in folder "6 Ways to Increase Heat Treating Production". *Cambridge Wire Cloth Co.*

647. Heat Treating Equipment

Bulletin 820 gives detailed description with complete specifications on various size automatic quenching tanks for use with continuous heat treating equipment. *American Gas Furnace Co.*

648. Heat Treating Furnaces

Illustrated literature describes newest developments in gas and electric heat treating furnaces. *Westinghouse Electric Corp.*

649. Heat Treating Furnaces

Bulletin SC-153, illustrated in color, describes the fuel-fired batch and continuous furnaces used in production of small caliber ammunition. Back page contains handy reference table showing relation of heat treat furnace equipment to consecutive steps in production. *Surface Combustion Corp.*

650. Heat Treating Pots

New Bulletin T-205 lists 118 patterns available in Thermalloy heat treating pots, both round and rectangular, X-rayed and pressure tested for sound and economical service. *Electro-Alloys Div.*

651. Heat Treating Services

Booklet describes complete diversified facilities for steel, aluminum and magnesium heat treating. *Pearson Industrial Steel Treating Co.*

652. High Speed Steels

New booklet, "Why Desegatized", shows how these hi-carbon hi-chrome steels help to cut production costs with thorough carbide distribution providing extra toughness and strength. *Latrobe Electric Steel Co.*

653. Immersion Heating

Bulletin IE-11 gives complete details on how new immersion pots save time and money in melting soft metals. High thermal efficiency for both large and small units provides rapid heat recovery in one-third the time. *C. M. Kemp Mfg. Co.*

654. Induction Heating

New 60-page catalog, "TOCCO Induction Heating", tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft Co.*

655. Induction Heating

New bulletin "Induction Heating and Melting" contains the well-known Selector Chart and table giving heating and melting speeds for standard induction equipment. *Ajax Electrothermic Corp.*

656. Induction Heating

Illustrated bulletin on new 60-cycle induction furnace for heating aluminum, magnesium, copper and brass for forging, extrusion and rolling. *Loftus Engineering Corp.*

657. Induction Heating

Bulletin 1440 furnishes full details on the "Checklite" system for safety control through the use of oversized components built into every unit for longer service life and uninterrupted production. *Lindberg Engineering Co.*

658. Induction Heating

Illustrated booklet on low-frequency 60-cycle induction heating. *Magnethermic Corp.*

659. Induction Heating

12-page illustrated booklet giving 15 case histories of hardening, joining and annealing applications of induction heat. *Westinghouse Electric Corp.*

660. Induction Melting

8-page illustrated article describes use of induction melting in improved technique for rotor-casting. *Ajax Engineering Corp.*

661. Induction Melting

New bulletin 14-A tells how to master melting problems with a combination of melting speed, superfine control, and over-all economy provided by the Ajax-Northrup 20-kw. converter-operated induction furnace. *Ajax Electrothermic Corp.*

662. Industrial Planning
New book 127 tells how you can share in "round-table" discussion of planning expansi remodeling or modernization of your pla *Continental Industrial Engineers, Inc.*

663. Instruments
Bulletin W1823 tells of controlling, recordi and telemetering instruments. *Bristol Co.*

664. Insulation, Block
New 4-page folder on Superex block insulati tells economical advantages and lists outstandi properties by means of conductivity and heat l graphs and recommended thickness table. *Joh Manville.*

665. Iron, High Chromium
New booklet, "Abrasion-Resistant Hi Chromium Iron", furnishes a complete file of t best available information on how to make a use abrasion-resistant iron castings most e ciently. *Electro Metallurgical Co.*

666. Liquid Handling
Folder contains data on filtration, blending a reclamation systems as well as meters and stora facilities. *Bowser, Inc.*

667. Load Cells
Engineering data folders describing torsi bar load cells and cantilever-beam load cells measuring force in materials testing and otl applications. *Automatic Temperature Cont Co., Inc.*

668. Load Testing
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673. Metal Analysis
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674. Metal Cutting
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677. Metal-Treating Ammon
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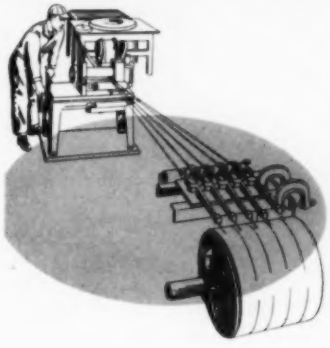

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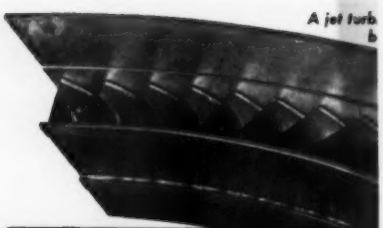
Phone: Pleasant 3-1291
THE KENILWORTH STEEL CO., 750 Boulevard, Kenilworth, New Jersey
Phones: N. Y., COrtlandt 7-2427; N. J., UNionville 2-6900
PRECISION STEEL WAREHOUSE, INC., 4423 W. Kinzie, Chicago • Phone: COlumbus 1-2700



New corrosion resista
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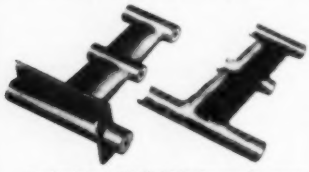
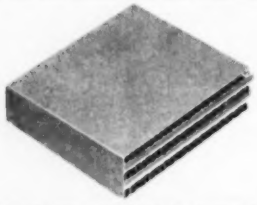
COLMONOY NICROBRAZ is a heat and
chrome alloy, developed primarily for
special alloys. It has these highly desira

NICROBRAZ resists high heat. A NICROBRAZ joint in a stainless steel assembly has a tensile strength equal to that of the parent metal while the assembly is operating at 2000° F. This quality ranks NICROBRAZ above any other known material for brazing parts for service in the high temperatures of modern aeronautical power plants.



Previously cast, this fuel injection nozzle support assembly is now stamped (right) of S 590 stainless alloy and then brazed (left) with NICROBRAZ.



Heat exchanger is made up of five corrugated and six flat sheets of 316 stainless steel, .010" thick. Brazed with NICROBRAZ in one operation.

Mercury bulb and tube assembly. Tube is .032" stainless steel with .006" I.D. hole. Five joints brazed in one operation with NICROBRAZ.

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662. Industrial Planning
New book 127 tells how you can share in a "round-table" discussion of planning expansion, remodeling or modernization of your plant. *Continental Industrial Engineers, Inc.*

663. Instruments
Bulletin W1823 tells of controlling, recording, and telemetering instruments. *Bristol Co.*

664. Insulation, Block
New 4-page folder on Superex block insulation tells economical advantages and lists outstanding properties by means of conductivity and heat loss graphs and recommended thickness table. *Johns-Manville.*

665. Iron, High Chromium
New booklet, "Abrasion-Resistant High-Chromium Iron", furnishes a complete file of the best available information on how to make and use abrasion-resistant iron castings most efficiently. *Electro Metallurgical Co.*

666. Liquid Handling
Folder contains data on filtration, blending and reclamation systems as well as meters and storage facilities. *Bowser, Inc.*

667. Load Cells
Engineering data folders describing torsion-bar load cells and cantilever-beam load cells for measuring force in materials testing and other applications. *Automatic Temperature Control Co., Inc.*

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682. Meters, Flow
Catalog C-12 gives complete line of meters and accessories for measuring pressure, vacuum and differential pressure of liquids and gases. *Meriam Instrument Co.*

683. Microcasting
New color-illustrated folder, "Microcast Case Histories", describes microcasting applications for both industrial and defense requirements. *Austenal Laboratories, Inc.*

684. Micro Hardness Tester
Bulletin MHT gives complete details of micro hardness tester. *Eberbach Corp.*

685. Micro Hardness Tester
Bulletin describes the Kentron micro hardness tester. *Kent Cliff Laboratories.*

686. Nickel Alloy Cast Iron
Bulletin describes eight types of Ni-resist, gives applications and comparative service data in many industrial fields. *International Nickel Co., Inc.*

687. Nickel Alloys
"Pickling Equipment for Severe Corrosive Condition" is a new booklet describing the successful use of nickel-base alloys in this application. *Haynes Stellite Co.*

688. Nickel Cast Irons
28-page basic reference bulletin compiled primarily for design engineers presents characteristics of modern nickel cast irons and illustrates their broad acceptance. *International Nickel Co., Inc.*

689. Nickel Silver
Paper dealing with detailed description of proper foundry procedure for production of sound castings from nickel silver. Also specification information. *R. Lavin & Sons, Inc.*

690. Oil Coolers
Bulletin No. 102 illustrates and describes batch type quenching oil cooling system. *Whitlock Mfg. Co.*

691. Oil-Gas Generator
4-page folder on use of generator which converts light fuel oil to a superheated oil vapor which, when mixed with air, burns in the same manner as utility gas. *Vapofer Corp.*

692. Phosphate Treatment
8-page booklet describing a paint-anchoring corrosion-resistant phosphate treatment for metals, with separate discussion of typical products to which process can be applied. *Octagon Process, Inc.*

693. Plating Barrels
4-page folder illustrates and describes the Daniels Plating Barrel designed to handle any barrel plating problem quickly and easily with a unique contact arrangement for maximum current distribution. *Daniels Plating Barrel & Supply Co.*

694. Plating Generators
Catalog MP-700 describes M-G set for electroplating, anodizing, electrocleaning, or electropolishing in either large or small-scale operations. *Columbia Electric Co.*

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695. Photomicrography
Full information furnished on Aristophot camera with Ortholux research microscope, providing the perfect team for easy, inexpensive photomicrography and photomacrography. *E. Leitz, Inc.*

696. Polishing
12-page booklet describing modern techniques of industrial polishing and buffing as related to the varied buffs, polishes and plating supplies. *Schaffner Mfg. Co.*

697. Potentiometers
Dynalog instruments for control of temperature, humidity, pressure, flow, etc. Details in bulletin 427. *Foxboro Co.*

698. Pots
Bulletin N-1 tells of pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Fuel Engineering Co.*

699. Precision Casting
4-page bulletin on precision investment casting in relation to product design. *Adapti Co.*

700. Precision Casting
12-page illustrated booklet on precision casting with emphasis on the most widely used equipment and supplies. Check list of applications in various fields included. *Alexander Saunders & Co.*

701. Precision Castings
8-page, well-illustrated brochure packed with informative engineering data on precision castings produced by the Mercast process. *Alloy Precision Castings Co.*

702. Presses
Press owner's manual contains complete operating and maintenance instruction for latest design straight-side double-crank presses. *E. W. Bliss Co.*

703. Presses, Bending
Steelweld presses for bending, forming, blanking, drawing and multipunching operations are described in catalog No. 2010. *Cleveland Crane & Engineering Co.*

704. Protective Chemicals
Quick reference list of rust-proofing, paint-bonding and metal protective chemicals is intended for all fabricators of steel, zinc and aluminum products. *American Chemical Paint Co.*

705. Punch Presses
Catalog TC describes line of twin column punch presses. *Wales-Strippit Corp.*

706. Pyrometer
New circular gives complete information on Xactemp pyrometers. New Type LT-840 and all accessories are illustrated and described. *Claud S. Gordon Co.*

707. Pyrometer
Catalog No. 165 describes improved Pyro surface pyrometer. Eight instruments in one, it handles all surface and sub-surface temperature measuring jobs. *Pyrometer Instrument Co.*

708. Pyrometers
Two portable models, suitable for plant and laboratory, are described in Bulletin PPY-1. *Wheelco Instruments Co.*

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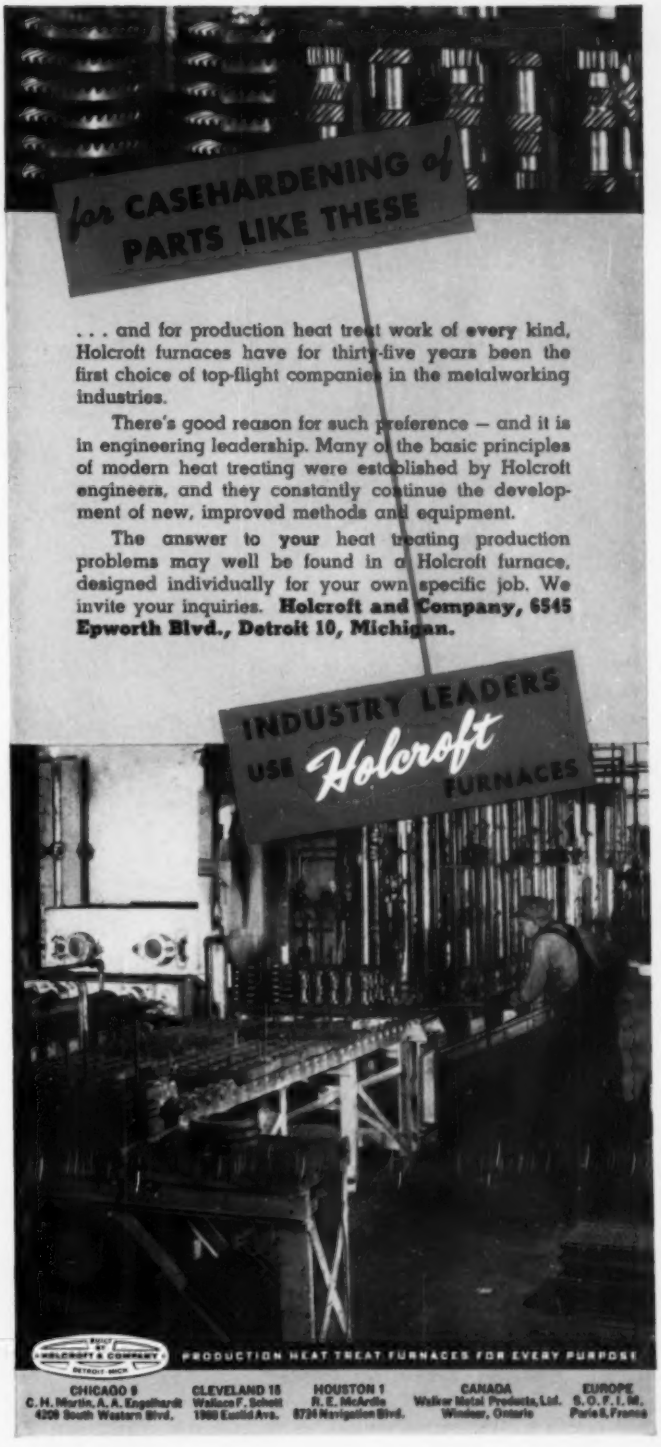
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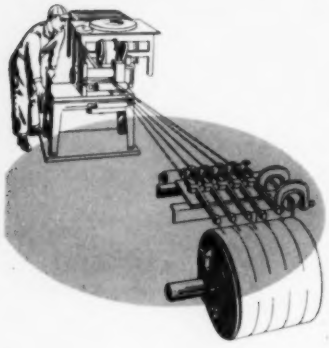

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THE KENILWORTH STEEL CO., 750 Boulevard, Kenilworth, New Jersey
Phones: N. Y., COrtlandt 7-2427; N. J., UNionville 2-6900

PRECISION STEEL WAREHOUSE, INC., 4425 W. Kinzie, Chicago • Phone: COlumbus 1-2700

709. Quenching Additive

New quenching additive described in "Quenzine Story" along with other heat treating compounds. *Aldridge Industrial Oils, Inc.*

710. Radioisotopes

Booklet on use of isotopes as tracers in industrial research and testing. *United States Testing Co., Inc.*

711. Recorder

Bulletin CL-1 describes the Wheelco Capaciline with "straight-line" temperature control for use on any kind of heating equipment such as ovens, furnaces, kilns, etc. Available in self-contained unit or as built-in feature of the Capacilog. *Wheelco Instruments Co.*

712. Refractories

Complete details on refractory cements for every nonferrous melting operation are available in catalog 863. *Norton Co.*

713. Rolling Mills

42-page illustrated book on development of the continuous strip mill and other equipment for processing ferrous and nonferrous metals. *United Engineering and Foundry Co.*

714. Rust Preventives

10-page booklet on surface active agents useful as additives in the field of rust preventives. Chemical properties and availability of various oxygenated hydrocarbons. *Alox Corp.*

715. Salt Baths

Technical Bulletin No. H-25 describes Neutra-Gas process, a method of maintaining neutrality in chloride-base salt baths. *Park Chemical Co.*

716. Sand Blasters

Bulletin covers operation and applications of hydro-sand blast and core knockout equipment. *Pangborn Corp.*

717. Slitting

76-page book on economics and mechanics of doing your own slitting. *Yoder Co.*

718. Solder

36-page educational brochure on the properties and applications of solder. Profusely illustrated, with a resumé of technical data and solder specifications of ASTM, SAE, Federal and Military agencies. *American Smelting & Refining Co.*

719. Specimen Mount Press

New bulletin describing AB Speed Press. Features include use of preheated premolds, rapid closing and universal application for thermosetting or thermoplastic materials in 3 sizes. *Buehler Ltd.*

720. Stampings

Attractive 26-page booklet contains reprint of paper on "How Modern Stamping Techniques Can Help Conversion". *Leake Stamping Co.*

721. Steel Bars

New wall chart of 275 different grades of standard, special and alloy steel bars shows chemical analyses and other data. *LaSalle Steel Co.*

722. Steels, Low-Alloy

You can have one-third more production through the use of Hi-Steel, which has nearly twice the working strength of ordinary steels plus the ability to stand up under impact loads. Booklet available. *Inland Steel Co.*

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November, 1951

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723. Steels, Low-Alloy
Well-illustrated, 8-page folder on N-A-X low-alloy steels lists physical properties and test specifications. *Great Lakes Steel Corp.*

724. Steels, Stainless
"Working Data" book describes Stainless No. 10 and other stainless and heat resisting steels. *Carpenter Steel Co.*

725. Steels, Stainless
Weekly lists with analyses of all plates in stock will keep you regularly informed on latest data. *G. O. Carlson, Inc.*

726. Stress-Relieving
New 4-page catalog folder describes how many unnecessary cleaning operations can be eliminated by new, practical, steam Homo method for stress-relieving of small brass parts. *Leeds & Northrup Co.*

727. Subzero Freezer
4-page folder on portable freezer, 110-volt a.c., operating to —165° F., for hardening, stabilizing, testing, shrink fitting. *Webber Appliance Co., Inc.*

728. Surface Inspection
8-page folder explaining applications and equipment for Faxfilm, a plastic-replica process to show roughness, wear, grain and other surface conditions. *Brush Development Co.*

729. Tantalum Equipment
28-page booklet contains useful information on the chemical and physical properties of tantalum, and detailed engineering descriptions of single and multiple tube heaters, coils, heat exchangers, condensers, hydrochloric acid absorbers, instrument protection, tubing and fittings. 72 illustrations and four tables. *Fansteel Metallurgical Corp.*

730. Temperature Control
New catalog of improved pyrometer supplies gives data on thermocouples, protection tubes, thermocouple and lead wire, insulations and terminal heads. *Arklay S. Richards Co., Inc.*

731. Temperature Control
Folder N-33-640(1) presents both immersion thermocouple and immersion rayotube equipment for molten steel temperature measurement in 275 ton openhearth furnaces down to 1000-pound high-frequency induction furnaces. *Leeds & Northrup Co.*

732. Tensiometer
8-page illustrated bulletin on tensiometer, a device for continuous tension indication of cold rolled strip in steel, brass and aluminum mills, describes the mechanical and electrical operation of the equipment and its possible applications. *General Electric Co.*

733. Testing
Literature available on tensile and Brinell testing machines. *Detroit Testing Machine Co.*

734. Testing
Folder on chemical, spectrographic, physical and metallographic services. *United States Testing Co., Inc.*

735. Testing Machines
New 30-page catalog on screw power universal testing machines and accessories includes illustrations and details of construction and specifications. Also information on special tools for different tests. *American Machine & Metals, Inc.*

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736. Testing Machines
Illustrated folder describes special features and operation of universal testing machine for tensile, compression and transverse tests. *Steel City Testing Machines, Inc.*

737. Textured Metal
Conservation handbook tells how three-dimensional sheet will help you save on metal consumption. *Rigidized Metals Corp.*

738. Tool & Lab Furnace
New literature on hardening and tempering furnace designed to give automatic control of the entire temperature range from 300 to 2200° F. *K. H. Huppert Co.*

739. Tool Maintenance
New compact 72-page booklet gives instructions on maintenance of alloy and high speed cutting tools. *Carborundum Co.*

740. Tool Steels
"Tooling up for Plastics" is a practical guide to the selection, application and heat treatment of steels for plastic molding. *Carpenter Steel Co.*

741. Tool Steels
New data on Ryerson VD steel and Ry-Alloy tells how to buy the proper tool steel with safety and confidence. *Jos. T. Ryerson & Son, Inc.*

742. Torch Tips
8-page catalog of replacement cutting and welding tips suitable for torches made by 16 manufacturers. *The National Torch Tip Co.*

743. Tubes, Bars, Steel
New stock list now available on 52100 tubing and bars as well as ring forgings. *Peterson Steels, Inc.*

744. Tubing
For full information on analyses available, production limits, commercial tolerances, temper designations and product descriptions of Seamless and Weldrawn tubing, send for bulletin 32. *Superior Tube Co.*

745. Turbo-Compressors
Bulletin No. 107-C, "The Turbo Compressor Data Book", gives a variety of experience in pneumatic engineering. No. 126-A describes the turbo compressor listing more than 160 standard capacities. *Spencer Turbine Co.*

746. Ultrasonic Testing
Commercial services using reflectoscope and reflectogage are described in Bulletin 50-105. *Sperry Products, Inc.*

747. Vacuum Impregnation
32-page brochure explaining process and including such applications as sealings of castings, impregnation of oilless bearings and emery wheels. *F. J. Stokes Machine Co.*

748. Vacuum Metallurgy
Bulletin entitled "National Research Corp. and Vacuum Metallurgy" gives brief résumé of the vacuum metallurgical operations and background of this company and of the research and development facilities and services available to the metallurgist. *National Research Corp.*

749. Vapor Degreasing
Pamphlet on properties and use of trichlorethylene as a solvent for vapor degreasing of metal parts. *Niagara Alkali Co.*

750. Wax Injection Press
4-page folder giving specifications and description of press for production of wax patterns for precision casting. *Alexander Saunders & Co.*

751. Welding Accessories
New 16-page arc-welding accessories catalog includes everything from headshields to books on welding. *Hobart Brothers Co.*

752. Welding Electrodes
16-page brochure, Bulletin AR51-1, "Alloy Welding Electrodes for Defense Production", describes electrodes for armor, high-temperature alloys, high strength steels and special applications. *Alloy Rods Co.*

753. Welding Equipment
Cadweld process and complete list of arc-welding accessories are described in catalog. *Erico Products, Inc.*

754. Welding Equipment
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709. Quenching Additive
New quenching additive described in "Quenzine Story" along with other heat treating compounds. *Aldridge Industrial Oils, Inc.*

710. Radioisotopes
Booklet on use of isotopes as tracers in industrial research and testing. *United States Testing Co., Inc.*

711. Recorder
Bulletin CL-1 describes the Wheelco Capaciline with "straight-line" temperature control for use on any kind of heating equipment such as ovens, furnaces, kilns, etc. Available in self-contained unit or as built-in feature of the Capacilog. *Wheelco Instruments Co.*

712. Refractories
Complete details on refractory cements for every nonferrous melting operation are available in catalog 863. *Norton Co.*

713. Rolling Mills
42-page illustrated book on development of the continuous strip mill and other equipment for processing ferrous and nonferrous metals. *United Engineering and Foundry Co.*

714. Rust Preventives
10-page booklet on surface active agents useful as additives in the field of rust preventives. Chemical properties and availability of various oxygenated hydrocarbons. *Alox Corp.*

715. Salt Baths
Technical Bulletin No. H-25 describes Neutra-Gas process, a method of maintaining neutrality in chloride-base salt baths. *Park Chemical Co.*

716. Sand Blasters
Bulletin covers operation and applications of hydro-sand blast and core knockout equipment. *Pangborn Corp.*

717. Slitting
76-page book on economics and mechanics of doing your own slitting. *Yoder Co.*

718. Solder
36-page educational brochure on the properties and applications of solder. Profusely illustrated, with a resume of technical data and solder specifications of ASTM, SAE, Federal and Military agencies. *American Smelting & Refining Co.*

719. Specimen Mount Press
New bulletin describing AB Speed Press. Features include use of preheated premolds, rapid closing and universal application for thermosetting or thermoplastic materials in 3 sizes. *Buehler Ltd.*

720. Stampings
Attractive 26-page booklet contains reprint of paper on "How Modern Stamping Techniques Can Help Conversion". *Leake Stamping Co.*

721. Steel Bars
New wall chart of 275 different grades of standard, special and alloy steel bars shows chemical analyses and other data. *LaSalle Steel Co.*

722. Steels, Low-Alloy
You can have one-third more production through the use of Hi-Steel, which has nearly twice the working strength of ordinary steels plus the ability to stand up under impact loads. Booklet available. *Inland Steel Co.*

723. Steels, Low-Alloy
Well-illustrated, 8-page folder on N-A-X low-alloy steels lists physical properties and test specifications. *Great Lakes Steel Corp.*

724. Steels, Stainless
"Working Data" book describes Stainless No. 10 and other stainless and heat resisting steels. *Carpenter Steel Co.*

725. Steels, Stainless
Weekly lists with analyses of all plates in stock will keep you regularly informed on latest data. *O. O. Carlson, Inc.*

726. Stress-Relieving
New 4-page catalog folder describes how many unnecessary cleaning operations can be eliminated by new, practical, steam Homo method for stress-relieving of small brass parts. *Leeds & Northrup Co.*

727. Subzero Freezer
4-page folder on portable freezer, 110-volt a.c., operating to —165° F., for hardening, stabilizing, testing, shrink fitting. *Webber Appliance Co., Inc.*

728. Surface Inspection
8-page folder explaining applications and equipment for Faxfilm, a plastic-replica process to show roughness, wear, grain and other surface conditions. *Brush Development Co.*

729. Tantalum Equipment
28-page booklet contains useful information on the chemical and physical properties of tantalum, and detailed engineering descriptions of single and multiple tube heaters, coils, heat exchangers, condensers, hydrochloric acid absorbers, instrument protection, tubing and fittings. 72 illustrations and four tables. *Fansteel Metallurgical Corp.*

730. Temperature Control
New catalog of improved pyrometer supplies gives data on thermocouples, protection tubes, thermocouple and lead wire, insulations and terminal heads. *Arklay S. Richards Co., Inc.*

731. Temperature Control
Folder N-33-640(1) presents both immersion thermocouple and immersion rayotube equipment for molten steel temperature measurement in 275 ton openhearth furnaces down to 1000-pound high-frequency induction furnaces. *Leeds & Northrup Co.*

732. Tensiometer
8-page illustrated bulletin on tensiometer, a device for continuous tension indication of cold rolled strip in steel, brass and aluminum mills, describes the mechanical and electrical operation of the equipment and its possible applications. *General Electric Co.*

733. Testing
Literature available on tensile and Brinell testing machines. *Detroit Testing Machine Co.*

734. Testing
Folder on chemical, spectrographic, physical and metallographic services. *United States Testing Co., Inc.*

735. Testing Machines
New 30-page catalog on screw power universal testing machines and accessories includes illustrations and details of construction and specifications. Also information on special tools for different tests. *American Machine & Metals, Inc.*

736. Testing Machines
Illustrated folder describes special features and operation of universal testing machine for tensile, compression and transverse tests. *Steel City Testing Machines, Inc.*

737. Textured Metal
Conservation handbook tells how three-dimensional sheet will help you save on metal consumption. *Rigidized Metals Corp.*

738. Tool & Lab Furnace
New literature on hardening and tempering furnace designed to give automatic control of the entire temperature range from 300 to 2200° F. *K. H. Huppert Co.*

739. Tool Maintenance
New compact 72-page booklet gives instructions on maintenance of alloy and high speed cutting tools. *Carborundum Co.*

740. Tool Steels
"Tooling up for Plastics" is a practical guide to the selection, application and heat treatment of steels for plastic molding. *Carpenter Steel Co.*

741. Tool Steels
New data on Ryerson VD steel and Ry-Alloy tells how to buy the proper tool steel with safety and confidence. *Jos. T. Ryerson & Son, Inc.*

742. Torch Tips
8-page catalog of replacement cutting and welding tips suitable for torches made by 16 manufacturers. *The National Torch Tip Co.*

743. Tubes, Bars, Steel
New stock list now available on 52100 tubing and bars as well as ring forgings. *Peterson Steels, Inc.*

744. Tubing
For full information on analyses available, production limits, commercial tolerances, temper designations and product descriptions of Seamless and Weldrawn tubing, send for bulletin 32. *Superior Tube Co.*

745. Turbo-Compressors
Bulletin No. 107-C, "The Turbo Compressor Data Book", gives a variety of experience in pneumatic engineering. No. 126-A describes the turbo compressor listing more than 160 standard capacities. *Spencer Turbine Co.*

746. Ultrasonic Testing
Commercial services using reflectoscope and reflectogage are described in Bulletin 50-105. *Sperry Products, Inc.*

747. Vacuum Impregnation
32-page brochure explaining process and including such applications as sealing of castings, impregnation of oilless bearings and emery wheels. *F. J. Stokes Machine Co.*

748. Vacuum Metallurgy
Bulletin entitled "National Research Corp. and Vacuum Metallurgy" gives brief resume of the vacuum metallurgical operations and background of this company and of the research and development facilities and services available to the metallurgist. *National Research Corp.*

749. Vapor Degreasing
Pamphlet on properties and use of trichlorethylene as a solvent for vapor degreasing of metal parts. *Niagara Alkali Co.*

750. Wax Injection Press
4-page folder giving specifications and description of press for production of wax patterns for precision casting. *Alexander Saunders & Co.*

751. Welding Accessories
New 16-page arc-welding accessories catalog includes everything from headshields to books on welding. *Hobart Brothers Co.*

752. Welding Electrodes
16-page brochure, Bulletin AR51-1, "Alloy Welding Electrodes for Defense Production", describes electrodes for armor, high-temperature alloys, high strength steels and special applications. *Alloy Rods Co.*

753. Welding Equipment
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METAL PROGRESS, 7301 Euclid Avenue, Cleveland 3, Ohio

November, 1951

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ON ONE COMPRESSOR SHAFT

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STRESSPROOF®

REPLACED *ALLOY* STEEL!

Originally, this compressor shaft was machined from A4615 alloy steel, then carburized, quenched, cleaned, straightened, and ground twice. When the manufacturer changed to new *Ground and Polished STRESSPROOF* for this part, machining was the only operation required—all other operations were eliminated! The result: faster production and an over-all savings of 59c per shaft.

This case is typical of the dramatic results possible with *Ground and Polished STRESSPROOF*—the finest ground bar steel produced. This bar eliminates many costly manufacturing operations because of its unique combination of four important qualities in-the-bar: strength... wearability... minimum warpage... accurate polished surface. And this sensational steel machines fully 50% faster than heat-treated alloys of the same hardness!

INVESTIGATE, NOW!

Most of today's Ground and Polished STRESSPROOF is going into defense jobs. Occasionally some sizes of bars are available for testing purposes.

La Salle STEEL CO.

1424 150th Street, Hammond, Indiana

Manufacturer of the Most Complete Line of Carbon and Alloy Cold-Finished and Ground and Polished Bars in America

Where Production And Precision Count

AUTOMOTIVE FORGINGS

CONNECTING RODS

PINION BLANKS

New Ajax-Northrup heater for automotive work has 8 heating stations, 30 interchangeable heating units. Heats billets from one to four inches, rounds or squares, to 2250°F at rate of 7500 to 8500 pounds per hour.

TRANSMISSION GEARS

AXLE SPINDLES

USE AJAX-NORTHRUP INDUCTION HEAT

Here's proof of Ajax-Northrup's ability to do the *tough* jobs . . . long run, high speed forging to exacting specifications.

The *connecting rod* billets are press-forged to a tolerance of 2 ounces. Smaller billets and elimination of scale give steel savings up to 20%. Production is increased 40%.

Ten tons of steel a day are saved by forging the *axle spindles* with improved methods based on scale-free induction heat. 16 men do the work of 46, and better fiber flow increases fatigue resistance of finished forgings by 17%.

The story's the same for gears, shafts, and countless other Ajax-heated forgings: Better forgings, at lower overall costs, with less steel. Call on our 35 years of induction heating experience—write us today.

SEND FOR NEW INDUCTION HEATING AND MELTING BULLETIN

133

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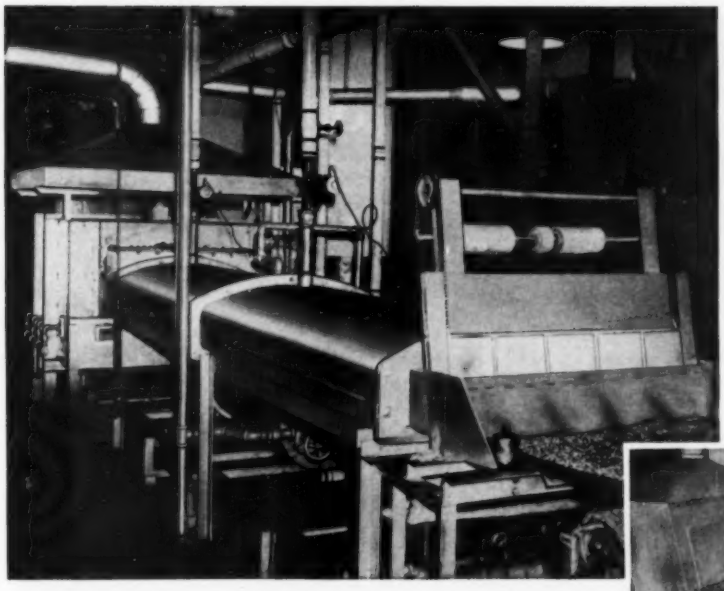
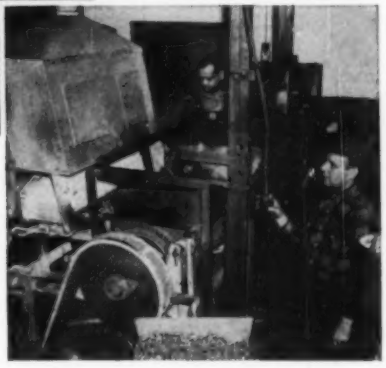


Charging end of the Stewart Bright Annealing Furnace showing blanks for P-K self-tapping screws coming off the Nichrome* conveyor belt made by Audubon Wire Cloth Corp. Furnace has been in continuous operation for more than 35,000 hours.

Discharge end of the furnace, at Parker-Kalon Corp., New York. Feeding is by an automatic electrically operated loader.



NICHROME* muffle passes 35,000-hour mark in non-stop performance at PARKER-KALON®

. . . and it's still going strong!

Does that make the Parker-Kalon Corp. happy? We should say so! Especially when they recall how, every year and a half, they used to mark time during a two-week shutdown. For that's how often they had to take down their annealing furnace to install a new muffle and belt. And the cost wasn't the worst of it . . . though it was plenty. What really hurt was the disruption of production schedules.

But that's all history now. Parker-Kalon anneals and normalizes its famous P-K self-tapping screws, thumb screws, wing nuts, and socket screws in a Sunbeam Stewart Bright Annealing Furnace equipped with a Nichrome* muffle and metal-woven belt. It operates at high annealing and normalizing temperatures, and handles a load that P-K's Production Manager, Harold Rosenberg, modestly describes as "substantially in excess of the 500-pounds-per-hour rated capacity."

The Nichrome* muffle and belt have been running at operating temperature for 35,000 hours, and they have never known a shutdown in four years. Yet neither shows any appreciable signs of wear or breakdown. And they are still going strong.

In similar ways, for over 35 years, we have been helping manufacturers meet their heat-treating requirements, to speed up operations, increase production, and cut costs. If you have such a problem, we invite you to consult with us. Although the present emergency's demands upon our resources are unprecedented, we shall gladly serve you to the limit of our ability.

Nichrome* is manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

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WHY DO FORGEMEN LIKE THE NEW MAXIPRES?

Because NATIONAL has engineered *23 distinctly new forging press features* into the new MAXIPRES, including:

Disc Brake
Water-cooled, trouble-free.

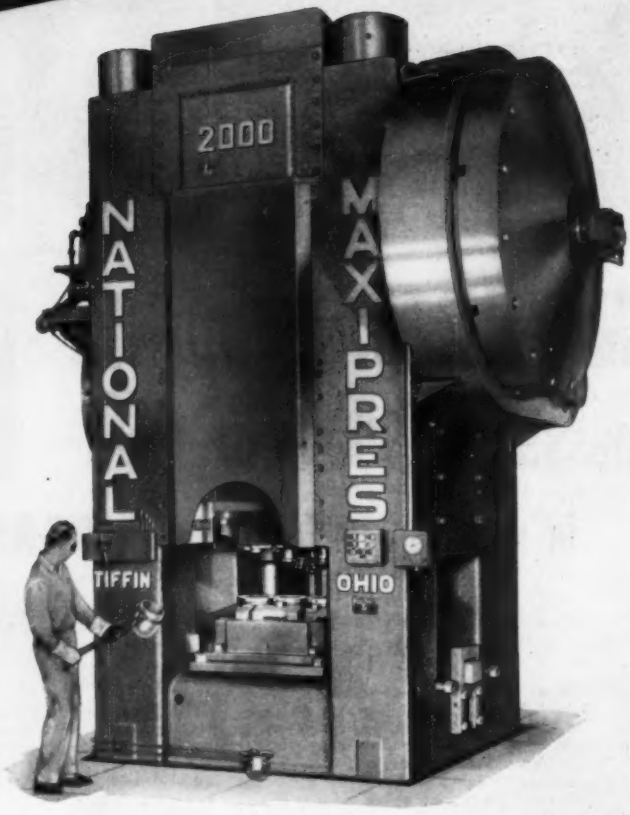
High-Capacity Clutch
Indestructible driving keys, 23% more ability.

Bigger Eccentric
Shaft strength 30% greater.

Tonnage Indicator
Blow-by-blow reading in tons.

Most modern forge shops have always preferred the MAXIPRES for its rugged construction and reliable operation, *plus* NATIONAL'S superiority in die design and service.

Now—the *new* MAXIPRES, *designed for the times*, is ready to fulfill the expanding requirements of the fast-moving forging industry.



MAXIPRESSES are available in 13 sizes from 300- to 8,000-ton.

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DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES—MAXIPRESSES—COLD HEADERS—AND BOLT, NUT, RIVET, AND WIRE NAIL MACHINERY

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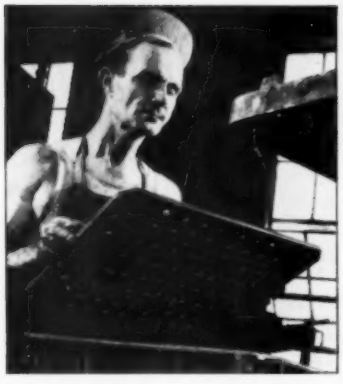
"EDCO BOTTOM BOARDS eliminate swelled castings"



Above photo shows Mid-City Foundry Company molder placing EDCO DOWMETAL Bottom Board on flask preparatory to pressing. Mid-City Foundry produces high quality gray iron and alloy castings.

Take a tip from E. F. Dublinski. He speaks from experience in saying —"EDCO DOWMETAL Bottom Boards eliminate swelled castings". Since switching to magnesium boards, Mid-City Foundry does not have castings ruined through swelling caused by depressions burned into out-dated wood boards.

EDCO DOWMETAL Bottom Boards help produce castings that are true to pattern. The exclusive grooved and vented design permits escape of gasses, and insures mold stability. Causes for rejects are kept to a minimum.

"We consider EDCO DOWMETAL Bottom Boards as permanent equipment at Mid-City," adds E. F. Dublinski, "because they'll outlast wooden boards at least 30 to 1 and in no time at all pay for themselves."

Your molders will like handling these boards because they are light in weight, easy to stack, and there's no danger of splinters. EDCO DOWMETAL Bottom Boards will not warp or rot—there are no nails to come out, nothing to break or split—no upkeep.

Write us, or phone CApitol 7-2060 for price schedule and list of 74 standard sizes available from stock.

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persists even to the selection of containers which will most assuredly safeguard quality in transit . . . to give best results in metal-cleaning and degreasing.

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HEAT TREATING FURNACES

For ALUMINUM
Aging • Pre-heating
Solution heat treating

For FERROUS METALS
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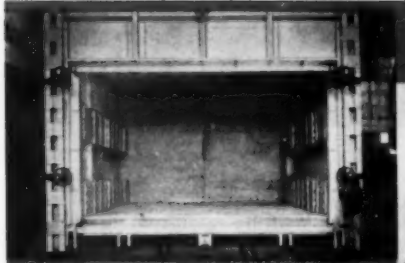
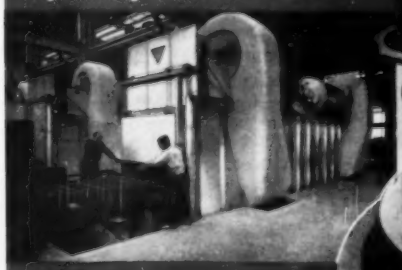
For all heating requirements up to 1350° F. where accurate heat control and uniformity in the work chamber is desired. Car bottom furnaces. Bottom entry quick quench furnace for solution heat treatment of aluminum. Conveyorized furnaces and all other material handling designs.

DESPATCH

Laboratory furnace for research and production control.



Despatch Stress Relief Furnace, gas fired car bottom type. Has automatic pre-heating, soaking and cooling control.



Despatch continuous conveyor furnace for steel heat treating.

Battery of Despatch pot type furnaces heat treating steel parts.

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dependable hardenability with maximum properties in low alloy boron steels

USE *Grainal* ALLOYS

For boron-treated steels, whether made in the electric furnace or in the open hearth, Grainal alloys are used successfully to increase hardenability.

A larger quantity of Grainal is usually required in electric furnace practice because of the higher nitrogen content characteristic of steels produced by this method. The conversion of the nitrogen content of the steel to an ineffective compound, as is done by some of the components of Grainal, permits a minimum amount of boron to produce the desired effects.

Grainal alloys are metallurgically balanced so that the larger additions required by electric furnace steels can be made safely without exceeding the boron limit for hot shortness.

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CHEMICALS AND METALS

if you do D.O. WORK
if you use ALLOY ARC WELDING ELECTRODES
this book* belongs on your desk
*Written by Richard K. Lee, vice-president in charge of Research and Engineering, and George M. Hohmann, manager of Defense Production Division.
ALLOY WELDING ELECTRODES for DEFENSE PRODUCTION
WELDING TECHNIQUES have changed markedly since World War II. This concise, authoritative, and timely brochure reviews past experience . . . describes new welding methods used in current Defense Production . . . and discusses new electrodes: their properties and uses.
SEND FOR your copy of Bulletin AR51-1, "Alloy Welding Electrodes for Defense Production," today.
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No Finer Electrodes Made . . . Anywhere
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AR-1

How the RCA *electron microscope* helps U. S. Steel forecast product quality

Robert M. Fisher, of United States Steel, viewing the image of a shadow-cast collodion replica of a polished and etched surface of steel—in the RCA Electron Microscope.

This remarkable picture shows size and distribution of carbides in a specimen of fine pearlite—clearly resolved by the RCA Electron Microscope. Magnification is 24,000 diameters!

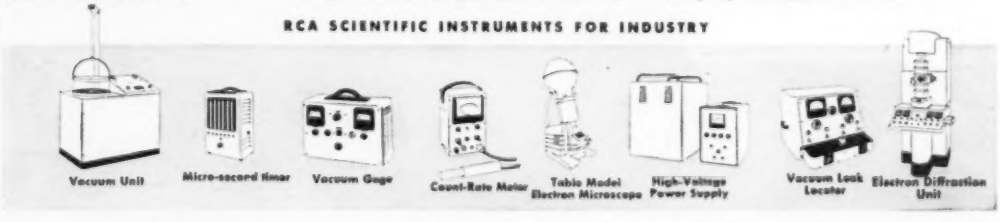
Says United States Steel Research:

"Since the properties of steel depend in very large measure on size and distribution of the carbides, one of our greatest uses for the Electron Microscope is the study of occurrence of carbides too small to be resolved by the optical microscope!"

Here is an instrument that can produce images at direct magnification from 500 to 23,000 diameters. (With the built-in camera, you can photograph specimens for enlargement up to 100,000 diameters.) You can resolve detail 20 to 100 times finer than the best light microscope, and bring every level of the specimen into sharp focus. And, by means of an electron diffraction adapter (supplied with the microscope), you can obtain both transmission and reflection diffraction patterns.

For more information, simply write Department 72W, Scientific Instruments, RCA Engineering Products, Camden, New Jersey. *(In Canada, write RCA Victor Company Limited, Montreal.)*

RCA SCIENTIFIC INSTRUMENTS FOR INDUSTRY



RADIO CORPORATION of AMERICA

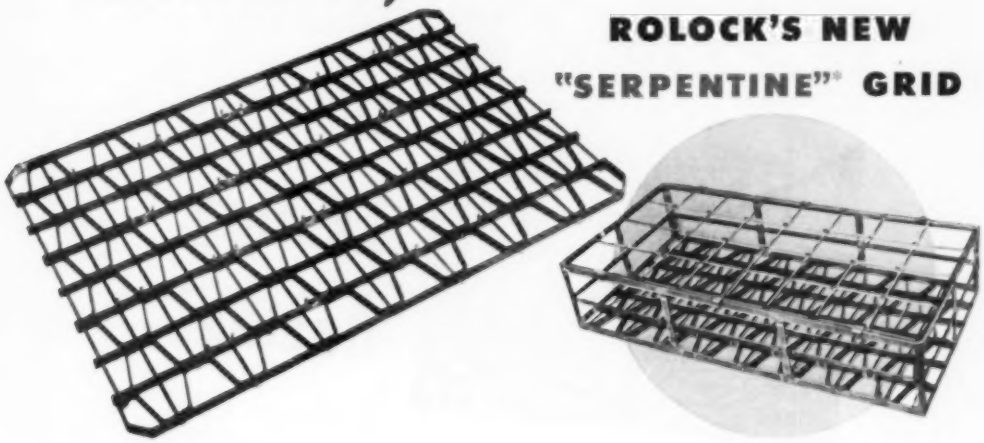
ROLOCK

HEAT AND CORROSION RESISTANT

FABRICATED ALLOYS

Introducing . . .

ROLOCK'S NEW "SERPENTINE"* GRID



Rolock engineers have designed this distinctly different "Serpentine" alloy grid to meet the rigid requirements of modern heat treating practices. It is very light in weight, yet capable of performing with minimum distortion for an extremely long service life . . . *never previously attained.*

Simple in design and fully articulated with loose tie rods, the grid is constructed with longitudinal bars as principal load carrying members, spaced with serpentine-like intermediate bars which serve to maintain vertical alignment.

Versatility of application is shown above. Inconel tray with positioning lugs used for copper brazing taurus assemblies at 2050°F. Basket, also of Inconel, used for annealing, quenching and acid pickling steel components in a continuous cycle. Full details on application.

*Patent applied for

Offices: PHILADELPHIA, CLEVELAND, DETROIT, HOUSTON, INDIANAPOLIS, CHICAGO, ST. LOUIS, LOS ANGELES, MINNEAPOLIS, PITTSBURGH

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

7A181

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Bronze Ornaments Retain Their Lasting Beauty!

The beauty of Brass or Bronze ornamental works is inherent in the metal from which it is cast. The architect and builder know that there is no substitute for Bronze when lasting beauty is essential.

Specify— LAVIN NON-FERROUS INGOT—*Quality*

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Refiners of Brass, Bronze and Aluminum

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REPRESENTATIVES IN PRINCIPAL CITIES

Your Stamping Ground for new products

with *Carpenter* Stainless

• Let's say you have a really good idea for an improved product in 195X. But there's just one hitch. You will need a Stainless Steel that has a combination of properties different from any Stainless ever made.

You might need the rustproof qualities of Stainless *combined with* special hardness limits to control spring-back of formed parts. Or, special tolerances combined with extreme ductility might be your answer to producing that good idea at a profit.

The job shown here was just that ticklish, when someone said, 'Let's call Carpenter'. If that sounds 'too easy' a way to solve a Stainless engineering problem, try it yourself. Drop us a line about your future products and the special things you would like Stainless Steel to do for you.

Doing the unusual with Stainless is a habit here at Carpenter. For example, one new steel is Carpenter Stainless No. 10, a chrome-nickel grade with an exceptionally low rate of work hardening. Maybe it has a place in your future planning, to solve the problem of cold working that can add to fabricating costs. Stainless No. 10 and many other Carpenter Stainless Steels are described in our 'Working Data' book. Would you like a copy?

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If it is necessary to control furnace temperatures in a heat-treating operation, it is equally important to control temperatures when quenching. Quenching in an oil bath controlled by a B & G *Hydro-Flo* Oil Cooling System is assurance that the standards of your product will be maintained.

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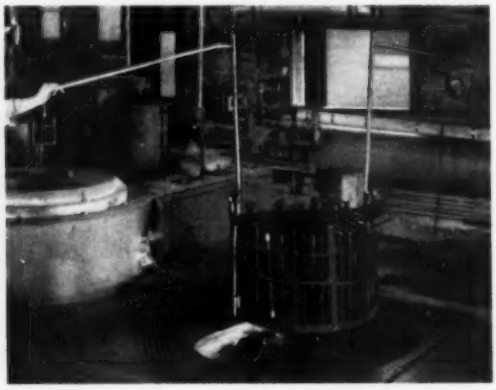
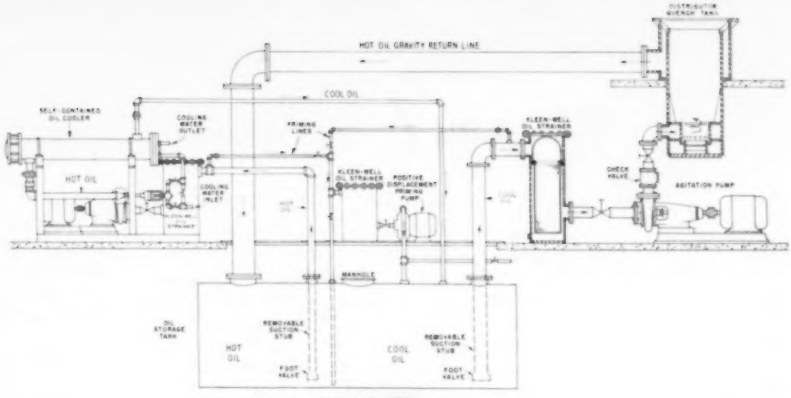
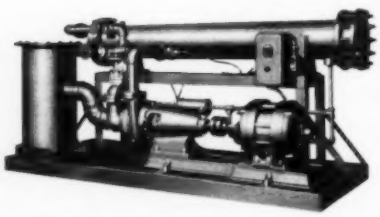
Write for literature. The B & G engineering staff is always ready to help with your quenching problems.





This diagram illustrates a batch quench oil cooling system as engineered and equipped by Bell & Gossett Company. The various B & G units include an Oil Cooler, Centrifugal Pumps, Oil Strainers and Quench Tank. A unique feature of this design is that the oil in the storage tank is maintained at two different temperatures.



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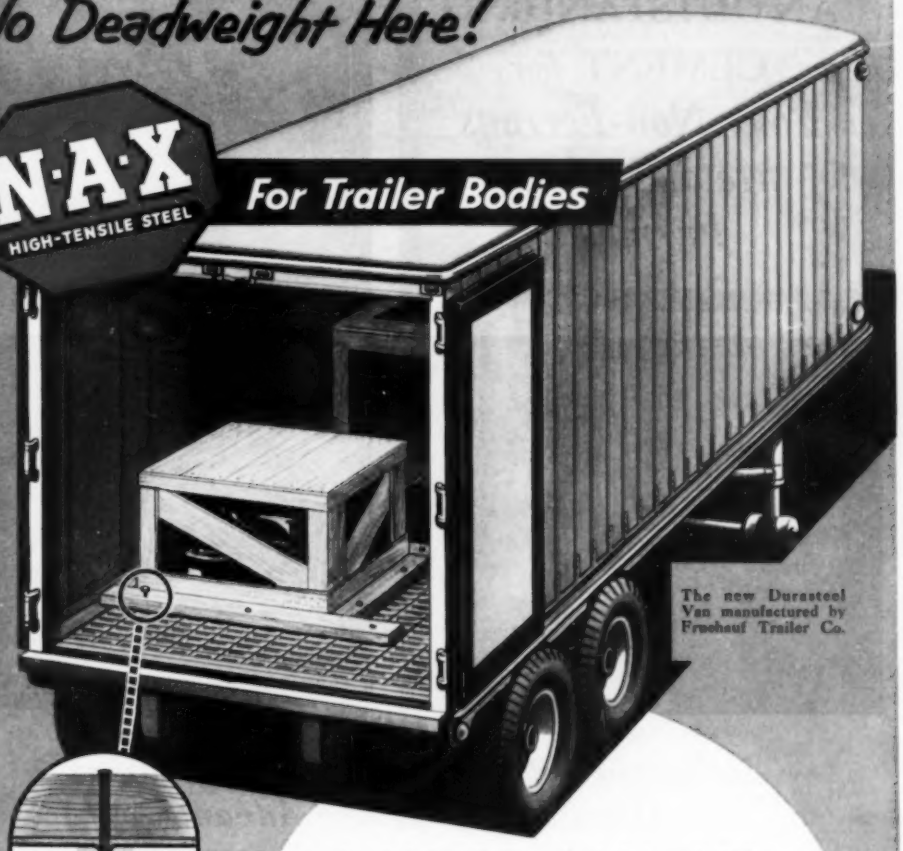

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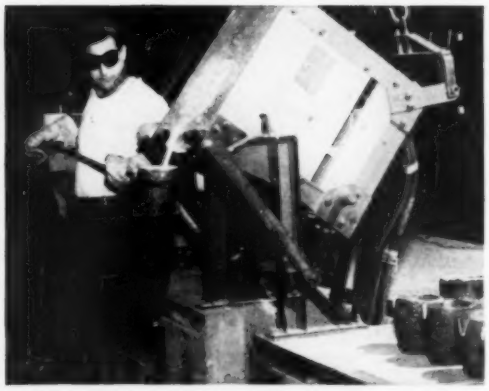

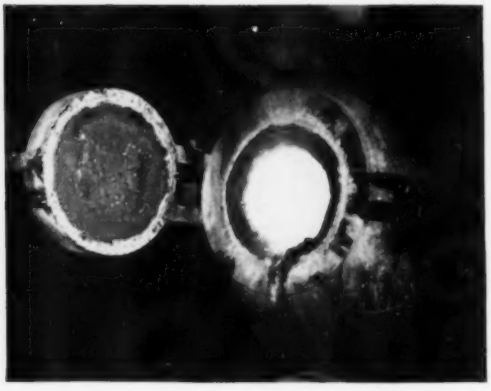

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Metal Progress

Vol. 60, No. 5 • November 1951

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"Let's try it without the stretcher levelling," said Art

For some time, an Inland Customer, who makes farm implements, had been buying 62½" x 128" sixteen gage cold rolled sheets for a certain part and had always specified that they be stretcher levelled and resquared to insure extra flatness.

The process of stretcher levelling and resquaring at the mill added substantially to the cost of the cold rolled sheets. Art Brackett*, the Inland sales representative on this account, questioned the need for this costly operation.

One day, on a visit to the customer's plant, he asked to take a look at the part being fabricated from this large sheet. He found that the stretcher levelled and resquared sheets were shipped from Inland to an independent fabricator for blanking. They were then shipped to Art's customer who further fabricated them and welded on bracing and framing sections before assembling them on his implements.

In talking to his customer's purchasing agent and production manager, Art suggested that the extra flatness achieved by stretcher levelling was lost by the time the sheet was assembled on the finished product and was, therefore, unnecessary. The customer changed his steel specification for this part, eliminating stretcher levelling and resquaring.

Result: A saving for Inland's customer of over $4.00 per implement—a saving that has already run into thousands of dollars! INLAND STEEL COMPANY, 38 South Dearborn Street, Chicago 3, Illinois.

Making Steel Do Your Job Well Is Inland's Job.

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Your Scrap Is Needed by the Steel Industry for National Defense

WORLD METALLURGICAL CONGRESS

- - - - - - -

BY THE PRESIDENT OF THE UNITED STATES OF AMERICA

A PROCLAMATION

WHEREAS the Congress of the United States, by joint resolution approved October 10, 1951, has extended its official welcome to the foreign metal scientists who will visit major American production centers and attend the World Metallurgical Congress to be held at Detroit, Michigan, from October 14 to 19, 1951, under the sponsorship of the American Society for Metals and with the cooperation of the Economic Cooperation Administration; and

WHEREAS the meeting of the World Metallurgical Congress will facilitate and encourage the exchange among scientists of the free world of scientific knowledge and industrial techniques in the field of metallurgy; and

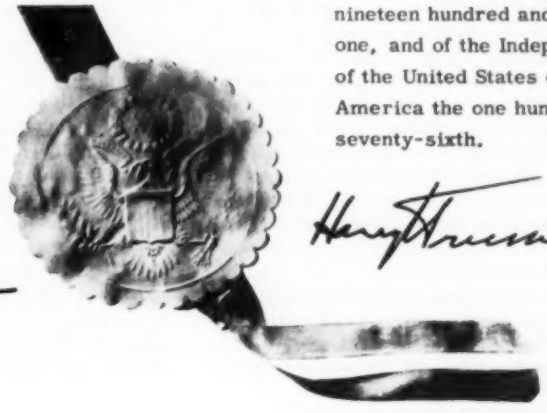
WHEREAS the advancement of methods for the conservation of available metal resources and the discovery and development of additional sources of supply are of paramount importance to the mutual security and well-being of the free nations of the world; and

WHEREAS the aforesaid joint resolution requests the President to grant recognition to the World Metallurgical Congress and to the American Society for Metals for its sponsorship of this world gathering of metallurgical scientists, and to call upon officials and agencies of the Government to assist and cooperate with such Congress:

NOW, THEREFORE, I, HARRY S. TRUMAN, President of the United States of America, do hereby extend recognition to the World Metallurgical Congress and commend the American Society for Metals for initiating and sponsoring this meeting. I also extend the welcome of this Government to the Congress and to the scientists attending its proceedings, and I request that all Federal departments and agencies assist and cooperate with the World Metallurgical Congress as occasion may warrant.

IN WITNESS WHEREOF, I have hereunto set my hand and caused the Seal of the United States of America to be affixed.

DONE at the City of Washington this eleventh day of October in the year of our Lord nineteen hundred and fifty-one, and of the Independence of the United States of America the one hundred and seventy-sixth.



Harry Truman

By the President:

Dean Acheson

Secretary of State.

More Metal, Wisely Used— the Key to Victory*

By Charles E. Wilson
Director
Office of Defense Mobilization
Executive Office of the President
Washington

I WELCOMED the opportunity to appear at this great meeting because I know of no audience that can be of more help in the grave situation faced by the Free World. This is the first World Metallurgical Congress — the first time, I am told, that expert metallurgists from many countries have gathered under one roof to exchange ideas and to coordinate the results of their research.

I wish I could say that expert metallurgists from *all* countries are here, but it is the tragic fact of our time that a large portion of the world has been sealed off by an iron curtain. Never before in world history has such a thing happened. Hundreds of millions of human beings behind that iron curtain are compelled to live in ignorance of what their fellow human beings are doing and thinking.

The world has witnessed many tyrannies, but never before have the minds of a large proportion of the human race been so ruthlessly and completely shackled. Men of science behind that iron curtain are not only cut off from their fellows; they are also compelled to prostitute themselves at the instance of the ruling power, or to suffer ostracism, imprisonment or death.

This is the central fact of our time, namely, that there are two worlds instead of one. There is the world that trembles under the hammer and sickle. And there is the world that is free to breathe, to think, to speak, to live and to hope.

But freedom has a heavy price. In Korea, Indo-China and Malaya the price is the blood of men, being shed for all of us. Elsewhere, the price is sweat and treasure, as the Free World girds itself to preserve its sacred principles and to stop the Kremlin's aggression in its numerous forms — subtle and overt.

It is my task, as Director of Defense Mobilization, to supervise the marshaling of the industrial forces that will serve to protect the United States and our allies and friends everywhere from the criminal conspiracy now being directed from the Kremlin. What we propose to do is to build the might of the Free World to so formidable a position as to discourage any general attack. In other words, the basic aim is to prevent another world conflict. We feel this can be done because we have learned that the enemy, while deaf to the appeals of peaceful persuasion, has a very acute ear for the language of strength. So we are filling his ear with the sounds of the greatest defense production program that has ever been launched. All over the United States, the magnificent industrial plant of the United States has begun to function. Before long, a flood of tanks, airplanes, guns, guided missiles, atomic weapons will flow from our factories; at the same time, the entire productive base of our economy is being enlarged to increase our supplies of steel, aluminum, copper, nickel, rubber, chemicals, petroleum, electric power and other fundamental elements.

In the first half of 1952, we are going to need tremendous amounts of metals for the defense program. Our peak requirements will occur during this period, yet military deliveries are not scheduled to reach their peak until some time during the first half of 1953.

I think a word of explanation is in order, since a very natural question is: "What are you doing with all the steel and aluminum that you are taking?"

The answer is that there is a long gap, or lead-time, between the day when we undertake to manufacture the complicated machinery of modern warfare and the day it is completed.

An extreme case is that of aircraft.

We are now shipping aluminum products from mills and foundries to aircraft manufacturers at about four times the pre-Korea rate. But, under current production schedules, it will take until the fall of 1952 before deliveries of aircraft to the military will show a four-time increase over mid-1950. (Total military requirements for aluminum are now eight or ten times as much as they were before Korea. In addition to sharply increased consumption by aircraft manufacturers, an approximately equal amount

*Broadcast from the closing meeting of the First World Metallurgical Congress, Detroit, October 19, 1951.

is required for other types of military equipment, little or none of which was being produced in the first half of 1950.)

A good part of whatever delay there is in aircraft production is due to the fact that we are building new types of aircraft, and our program — in this regard as in others — is a flexible one. Conditions change, weapons change, new developments occur. We're producing to prevent the next war, not to fight the last one. We're willing to risk criticism for not meeting a given schedule if, by pausing, we can get a thousand better weapons rather than twelve hundred old ones. In many instances, production is held up until the first items off the line are tested by the armed services to determine what modifications or improvements should be made before quantity production begins. Here the problem is not one of production, but of design. We could promptly fill the State of Texas if we had set out to build B-17's or B-29's. But the construction of the modern jets, with all their immensely intricate design and equipment, is necessarily slower.

I have spoken of the lag in aluminum from requirement-day to delivery-day. The steel situation is somewhat different; its average lead-time is somewhat shorter because much of the steel required by the military goes into civilian-type items or into such relatively simple forms as ammunition, for which rapid production can be obtained in a fairly short time. Moreover, considerable steel will go into the construction of industrial facilities and machines needed to increase defense production. This comes under the head of "expansion of the industrial base". Consequently, steel requirements may reach their peak early next year and decline, while production as a whole is still rising sharply and will continue to do so for many months.

METALS ARE LIMITING FACTOR

In general — and this is of particular point to this audience — the most important limiting factor in defense mobilization lies in the shortages of metals. To some of you from other countries, this will seem fantastic, considering the vast amounts of metals we have available.

I refer, for example, to the matter of steel. Our industry is now producing at a rate of more than 106,000,000 tons of ingot a year and its capacity is being enlarged to produce nearly 120,000,000 tons. You men in this audience realize the magnitude of these figures. You know they represent several times as much steel as the entire production of the Soviet Union. You know they are far in excess of the most optimistic forecasts of a few years ago, when a production of 100,000,000 tons of steel was considered "out of this world". Yet we still lack steel for our current needs, and we particularly lack alloying metals needed to produce the modern instruments of warfare.

Once we thought that there was almost an inexhaustible supply of iron ore in the Mesabi range, but the voracious demands of World War II and the present defense effort, plus the needs of a great and growing civilian economy, have brought that supply within sight of depletion. Fortunately, we can now look to the great stores of iron ore in Venezuela and Labrador to satisfy our future requirements.

In aluminum, for which so many new uses are being found, we are doubling capacity from the 700,000-ton pre-Korean level. But again, in this interim, we are hard put to supply our current needs.

Copper is a more serious problem, for even in the year 1950, before defense production really got under way, our civilian industries were using all the copper that was being mined in this country, plus large imports from Chile.

Nickel is in short supply, as the Canadian mines are being compelled to tunnel for it, so we are taking vigorous steps to reactivate the Nicaro deposit in Cuba. This project was scheduled to start producing by next March, but we now have strong hopes that the date will be moved up to January. Eventually it should add 10% to the Free World's supply.

We have increased domestic production of tungsten, as well as imports, but allocation of the metal will still be necessary for a considerable period. The story is the same with regard to molybdenum. We need more zinc, lead, magnesium and other metals.

As you know, the world is being searched for ore deposits, and intensive study is being made for better ways to extract and process them. It is important for American metallurgists and their colleagues from other lands to contribute their skill and energy to this hunt. The metals needed are distributed in many parts of the earth. We can't do anything about that distribution, but we can do a great deal about the distribution of facilities for utilizing the mineral deposits, and to see that they are employed in such a way as to produce the maximum potentiality for strength.

Our metal shortages offer a challenge to ingenuity and inventiveness, and this challenge is being met in many interesting ways. The men in this audience have made many contributions in the saving of metals by substitutions, and I

hope they will be inspired to make many more.

Aluminum is being saved by the use of gray iron in automotive parts. New molding methods permit the use of such iron in place of aluminum, even in castings requiring high dimensional accuracy. Plain carbon steel with protective coatings is being widely substituted for critical alloys and stainless steels.

Americans have found that boron-treated steel is very satisfactory for many civilian uses. As you know, boron serves to minimize or even eliminate several of the other alloying elements used extensively in munitions. Only very small amounts are needed per ton of steel, and the supply is ample, so its use will become an increasingly important conservation factor.

We are saving chromium by the use of clear organic coatings and enamels; likewise, substitute finishes are preserving copper, brass and bronze. Glass is replacing scarce metals in a wide variety of uses — in equipment, furnaces, chemical tanks and in building construction. Glass tubing can replace brass and copper tubing for some purposes, and glass is being used in small electrical condensers to replace mica. Porcelain enamels have proved reliable substitutes for stainless steel as corrosion resistant materials.

Of great importance in our campaign to eliminate waste and encourage substitutes is the progress in the construction industry. By redesigning certain types of structures, we are saving as much as 50% of the steel ordinarily used. In some cases, masonry, reinforced concrete and heavy timber eliminate entirely the use of structural steel.

I know you gentlemen are familiar with these processes, but I cite them as an indication that much more can be done to ease the pressure of mineral scarcities. There is a premium these days on mental fertility, just as there was in the time of the last war, when so many marvelous ideas were born.

LONG-RANGE PROBLEMS

While there is no cause for alarm over the current mineral shortages, since many of them are temporary in character, it is quite clear that the metallurgical resources and facilities of the whole Free World are going to have to be brought into play. The United States depends upon many other nations for the metals we need, at the same time that we are supplying raw materials and finished products to these other nations. The resources of the Free World must be pooled, as well as the brains, skill and energy of its metallurgists.

There is room for plenty of sober thought and action to solve our short-range problems; there is room for even more sober thought and action with regard to the long-range problems of mineral resources.

In the last half-century, the amount of metal taken from the earth is equal to that mined in all the previous thousands of years of history. In the last 150 years, the population of industrial nations has tripled but in the same period the demand for metals has increased a hundredfold. These trends inevitably lead to rapid mining of the known ore deposits, but there is an additional grave factor. I am sure you gentlemen, who have spent your lives in the study of metallurgy, must be appalled at the way in which modern warfare is depleting natural wealth.

I am sure you must reflect on the tragic waste of metals which has been going into the instruments of destruction during the twentieth century. The swords we are now making cannot be beaten into plowshares. They must be kept ready until such time — and God speed the day — when the two opposing worlds become one once more.

Meantime, the progress of science and industry is such that the minerals of the earth could be used to improve the living conditions of humanity everywhere. The steel that goes into tanks, guns and planes could be used for homes and schools and civilian factories. When we think of the perversion for war purposes of the natural wealth with which God has endowed the earth, we are struck with horror at the needless waste. And we must regard with loathing the leaders of the Soviet Union whose policies and ambitions have compelled the Free World to devote so much blood, time and treasure to defense.

But since that is the case, there is no alternative for the free nations but to march shoulder to shoulder in the mission to preserve their undying principles; to work side by side at the work bench and in the laboratory and to come together, as you men are doing in this great meeting, to discuss and resolve our common problems.

We can have the utmost confidence in the outcome. The Free World has the physical power to resist aggression; but — more important — it has the spiritual resources that lie in the right of men to worship God as they please, to think and speak freely, to live their lives as they see fit.

Tyrannies come and tyrannies go, but the universal principles of freedom and democracy will last forever!

Critical Points

BY THE EDITOR

The Real Problem Unsolved

MR. WILSON, in his address at the extraordinary farewell meeting of the World Metallurgical Congress, rightly stressed the need for an equitable distribution of available metals among the Free Nations and the utmost economy in their use. (This was the common topic of discussion among foreign conferees and their American counterparts all through the Congress.) Mr. Wilson's staff at the Office of Defense Mobilization is endeavoring to apportion the American supply of strategic metals wisely — a task made more difficult by the belated rush to build up stockpiles. In passing, the Editor may remark that, while attending some meetings of advisory groups in Washington, he was impressed by the O.D.M.'s administrative staff as gratifyingly competent and hard working; some of them were in similar positions a decade ago. This, together with the nature of their problems, indicates that we Americans have gone through a complete circle and are back in 1940, having learned little in the intervening decade about how to keep the supply of metals well ahead of the demand. That's the essential matter.

Some conversation revolved about the present situation of a marginal producer in the copper industry — that is, one who uses copper primarily, yet whose product is one which is more a luxury or a convenience than a necessity. What are his long-range prospects, if he cannot substitute satisfactorily some other more common metal — that is to say, magnesium, aluminum or iron? The Editor ventured the opinion that prospects of such a firm are clearly shown by a simple graph where tonnage is plotted vertically against time since 1900. One line — nearly horizontal — represents world production of new copper. The second line — rising sharply — represents the *essential* demands as indicated by the increasing use of electricity. The only argument is whether the two have yet intersected.

In Memoriam

It is with the most profound regret that the sudden and untimely death of Adolph Bregman must be recorded. He gave of his abilities to Metal Progress as Consulting Editor on matters concerning cleaning, plating, and finishing—subjects on which he had spent a lifetime of study and on which he was a leading consultant.

Secrecy Confused With Security

SHORTLY before one of these Washington conferences, President Truman issued his unfortunate order permitting all bureaucrats to operate behind a false veil of "security". No matter how this order may later be modified, the tendency is to reach too often for the rubber stamp "Secret" or "Restricted" or "Confidential" or "For Official Use Only". It is not a new temptation, as any experienced reporter well knows. I dare say it defeats its own purpose more often than it achieves good. As a minor (personal) instance, let me cite the impossibility in 1941 to pry loose any information in the time available about the Treasury's holdings (stockpile) of tungsten, even when studying the supply and demand of that essential metal for another governmental group. Perhaps such secrecy was partly responsible for the fact that there are still no important reserves of this truly essential metal — a situation recently divulged and which raised horrified comment from the daily press. No one outside a small group in Washington knew the true facts — no one could "raise a stink" that would demand correction.

It is hard for me to see any danger in giving the world (Russia included) the true metal statistics — including governmental stockpiles. Indeed, a clear idea of our mine, smelter and refinery production of any metal should be of far more strategic importance to a potential enemy than the size of a stockpile, yet an important function of the Bureau of Mines has always been to collect and publish annually those exact statistics.

Even in the production of an atomic bomb, the most rigid secrecy ever imposed on Americans attained no more than a four-year head start on the Russians. (This is the time between our test at Alamogordo and the first Russian

nuclear explosion.) However, in the business world, a four-year lead over your competitors is a safe and comfortable margin. One can presume that that situation also exists in national defense. Warlike and peaceful pursuits alike, interchange of information and cross-fertilization of ideas are essential for rapid progress, for maintaining this leadership. The Editor firmly believes that any firm which shuts its doors to intelligent visitors fences out far more than it fences in. It is so easy to confuse "secrecy" with "security"! True security of a democratic people requires the very minimum of secrecy.

The Demands of Speed

AIR MATERIEL COMMAND evidently had something of this sort in mind when organizing the recent parade of air weapons and associated equipment for American Ordnance Association at Wright-Patterson Air Force Base near Dayton, Ohio. For five hours a succession of take-offs, evolutions, landings, unloadings, refuelings, engine changes, fire-power demonstrations and bombings by the latest fighter, cargo and bomber aircraft left the spectators—largely industrialists—wide eyed and somewhat aghast at the fearsome things they had helped produce.

Well-organized displays, manned by knowledgeable personnel, also explained the principal investigations in the main divisions of the Air Research and Development Command. Especially interesting to this observer was the evident progress in guns, missiles, and servo-mechanisms. A machine gun that fires 20 rounds a second is unbelievable, even after you've seen five of them in a single group spew out a torrent of bullets. An ordnance report from Korea stated that 2,000,000 rounds of 50-caliber ammunition had been fired with only 17 stoppages from all causes—which (even after multiplying a few times for forgetfulness) is striking testimony to the adequacy of design and construction, and the efficacy of statistical control in manufacturing and inspection.

Much of the aviation work in progress is demanded by speed—the supersonic speed of aircraft. The belly of the fighter is completely filled with a jet engine; the wings are so thin there is no room to contain fuel tanks; the speeds are so fast that human reactions of the pilot are too slow—servo-mechanisms of the predicting or anticipating type are necessary. Pack all this, plus pressurizing and cooling systems for high-level flying, five machine guns and thousands of rounds of ammunition, into a sleek plane and there's hardly room for the pilot, even after all the equipment is refined by redesign to the smallest possible space and weight. In fact, it does not take much imagination to foresee the fighter without a pilot, a remote controlled battery or bombing platform, a guided supermissile, fast as lightning.

Associated improvements in aircraft guns include interchangeability—easy change of a worn barrel, or even more extensive changes for different calibers—and explosive projectiles. The World War II plane carried its own potential destroyer until its fuel tanks were adequately protected against incendiary bullets; now incendiaries are giving way to shattering, explosive missiles.

Any Anti-Submarine Weapons?

CONSIDERABLY less reassuring was a talk the previous day by Capt. H. P. Cooper, U. S. Navy, on anti-submarine weapons. Those who survived the two World Wars or who have read Winston Churchill's memoirs will recall how perilously close the German submarine came to winning. Even in World War II the sinkings in the Atlantic and Gulf all but throttled the European Allies until aircraft could accompany the convoys clear across and search for the killers far ahead along the route. In the Pacific our own subs practically exterminated Japanese commerce. And these were *slow* submarines, necessarily spending much of the time on the surface, and firing a straight-running torpedo. Today we have fast submarines able to overtake any freighter, capable of swimming below water indefinitely, vastly harder to detect at any distance, and firing a homing torpedo.

Today's anti-submarine weapons, as described by Captain Cooper, seem to be principally improvements on devices that all but failed in the last war. The so-called "killer submarine" is in reality a listening post. The most interesting proposal is a rocket launched from an escorting vessel, automatically trained on its target by sonic control, designed to keep the submarine out of range, a long way from its prey. Obviously such a device requires the adequate solution of many problems: First, locate your hidden enemy; next, get within range without scaring him and losing contact; next, fire a reliable amphibious missile that seeks its target automatically; finally, explode it close enough to the submarine to do some damage.

Maybe the problems associated with such a device are well toward solution, but the speaker

did not leave that impression on at least this listener. In any event, revolutionary changes in the submarine itself should require radically new defenses, if defense is possible — and it must be. Perhaps they remained unmentioned because they are reserved for surprising the enemy — a thoroughly justifiable reserve. It would be just too bad if they remained unmentioned because they do not yet exist!

Conferences for Conferees in Detroit

MOST of the Editor's time at the National Metal Congress and Exposition in Detroit was occupied as Chairman of American Conferees to Group No. 1 (pinch-hitting for E. G. Hill, director of metallurgy and development for Wheeling Steel Corp.). His comments must therefore be reserved to this activity, leaving notes about the Exposition to his associates, Messrs. Roast and Parina. These gentlemen also joined various groups of foreign conferees at a few of the plant visitations in the tours immediately preceding the Congress, and their reports in subsequent pages may be taken as indicative of the gratifying cooperation extended by nearly a hundred American firms in the metals industry.

While many opportunities were given for foreign conferees to discuss metallurgical problems with experts at the various cities visited enroute, conferences were arranged in Detroit for general discussions with Americans from far and near. Some 72 such Americans were members of the panel for Tour 1 on Steel Refining and Steel Making, and 80 topics for discussion were proposed, necessitating four general meetings and three meetings of sub-groups. Obviously from this mass of material only one or two highlights can be mentioned here.

Real Conservation at Algoma

FREQUENTLY a fundamental difference in viewpoint appeared in the comments of Europeans and Americans on individual processes. While generalizations are dangerous, it would appear that men overseas are more concerned with the economics of a single operation, whereas the Americans look at the operation from the standpoint of the over-all process. A wasteful method is tolerated by us if it is fast and satisfactory and saves more in time and capital charges than it wastes in materials. This circumstance led to some embarrassment. For example, when discussing conservation of chromium, it was acknowledged that the pressing demand for more and more tonnage required American furnaces to operate in such a way that 20% of the chromium in the cold charge is lost to the slag, whereas three quarters of that loss could have been saved by a more leisurely refining cycle. From this viewpoint, the best way to insure conservation of a metal is evidently to boost its price several times!

W. C. Kimball, works metallurgist for Algoma Steel Corp. of Sault Ste. Marie, Ontario, gave the outstanding example of alloy conservation. (The A.S.M. presented its apologies to the foreign travellers for not taking them into some of the outstanding Canadian shops, since the tours were limited to the United States by regulations issued by the Economic Cooperation Administration.) Up to recent months the favorite of users north of the border was the almost foolproof A.I.S.I. 4600 steel, but governmental orders converted this almost overnight to something similar to TS8600, whose alloy can largely be gained from the scrap on the charge. Canadian automotive and implement manufacturers had difficulty in heat treating it, due to the wide range of hardenability when alloys hugged the high or the low side of the specification — a difficulty removed by the steelmakers at Algoma by producing to a very close chemical composition. This was possible only with the aid of fast spectroscopic analysis.

The melter would know (or think he knew) how much metal was charged, and a quick analysis at melt-down would give the average alloy content. Suppose there exists 0.17% nickel. He then adds a carefully weighed amount of nickel to bring the content up to 0.38%. The bath is then analyzed, and if the result is 0.38, his guess was correct; otherwise his estimate of the weight of metal in the bath can be recomputed and he then knows *accurately* the amount of steel he is working with. Consequently he is able to make his further additions precisely, with the result that 90% of the heats now conform to the following specification: Nickel 0.40 to 0.44%; chromium 0.65 to 0.70%; molybdenum 0.08 to 0.12% — amazing to American and foreign commentators alike. Most of the chromium is added as an exothermic compound, ignited in the ladle just before tapping; final adjustment of carbon (according to carbometer charts computed for the usual content of manganese) is by graphite, also in the ladle. While this steel is on the low side of the hardenability band for TS8600, it is consistently there, and heat treating routines, once adjusted, can stay put.

Conservation of Strategic Metals in Germany*

By Karl P. Harten
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Vereins Deutscher Eisenhuettenleute
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THE PROGRESS OF CIVILIZATION and engineering has caused such a steady increase in consumption of all metals that the discovery and development of new sources of supply cannot always keep pace with the demand. If, in addition to this normal trend, an extraordinary demand arises, such as the necessity to prepare for the defense of freedom, a shortage of the most essential metals is likely to arise *all over the world*. Measures to conserve metals will be particularly necessary if a country is deficient in raw materials and if there is the risk that supplies from abroad will be held up.

The particular metals which will have to be rationed are not the same for all nations. However, in all countries cobalt, copper, chromium, manganese, molybdenum, nickel, columbium and tungsten will be in short supply. The following comments will be confined to these metals and examples will be given from experience gained in Germany.

Cooperation of Consumers — A consumer likes to choose his material in such a way that purchase plus maintenance represent the least cost. Frequently, he does not have dependable performance data; so he will then be unable to arrive at a positive and correct decision. Cautiously he continues to use the materials he is accustomed to; he is not inclined to switch over to the new materials until a sufficient amount of data has been gathered to insure that it carries no unsuspected risk. How long the introduction of a new alloy may be delayed by those considerations is indicated by the example of high speed tools of molybdenum steel which proved substantially equivalent to the conventional tungsten steels.

A decision will often be easier and conservation be quicker if dependable short-time tests are available. Consequently the search for these tests is a most important task. A good example of a short-time test is the end-quench test for hardenability proposed by Jominy and Boegehold in 1941 and named after the first. This test shortened the time necessary to substitute the triple-alloy steels for those relatively high in nickel.

Correct selection of a material presupposes considerable knowledge of the conditions actually encountered in its use and its capability to withstand the stresses. In this respect *users* can contribute much to the conservation of metals if they consider carefully which material will yield the highest possible performance per unit of alloy. It is wrong, for instance, to select a high speed steel according to the most severe conditions of operation encountered, whereas these may cover only a small proportion of the actual uses.

Prolonged investigations carried out in German plants have led to the decision to use the so-called ABC-III steel having approximately 2.5% molybdenum, 2.5% vanadium, and 3.0% tungsten to a great extent, since (with the usual cross sections of chip and normal cutting speeds) it is often the most favorable to use from the standpoint of plant economy. Refer in this respect to Fig. 1 and 2 in which the performance for roughing and for finishing cuts is indicated for five common grades of German high speed steels and one grade of cemented tungsten carbide.

We do not pretend that the material with the lowest content of alloy will always be the most economical. Figure 2 shows that the cemented carbide S-1, in spite of its high tungsten content of 74%, yields a higher performance per unit of tungsten than high speed steels with 12 to 18% tungsten. At still higher speeds than shown in the caption under Fig. 1 the superiority of the tungsten carbide is still more pronounced. That is the reason why we, in Germany, tend to use the cemented carbide alloy as far as modern machine tools available will permit its economical use.

An extended adaptation of the material to the particular use involved — which would be in the interest of the optimum utilization of a strategic metal — is certain to result in a larger number of types which, in itself, has some undesirable consequences. The quantities of material

*Address before the opening session, First World Metallurgical Congress, Detroit, October 14, 1951.

in stock will increase; not only is there danger of confusion, but usually different treatments (and sometimes more precise ones) may be necessary for the different grades. It is difficult to determine the point where the advantages of conservation outweigh these drawbacks.

CONSERVATION IN PROCESSING AND DESIGNING

Every manufacturer of a structure, machine or appliance endeavors to obtain as many finished articles from his raw material as possible. In this effort, however, he will have to keep costs at a low level. Sometimes a method of processing requiring a higher consumption of materials will be more economical. This is usually true, for instance, for tools which can be made either entirely of high alloy steel or as composites, wherein the working edges are welded or inserted in a body of plain carbon or low-alloy steel. It may happen that the composite tool will be more expensive because of a larger labor charge, and its performance will not compensate for the added cost. It is evident that such measures of conservation presuppose intelligent planning and allocating.

Similar conditions may be valid also for the use of clad material as substitutes for solid metal. Thin sheets (having a correspondingly thinner cladding) may be so much more expensive that the fabricated article will cost more than if it had been made completely of solid alloy. Below certain thicknesses of stainless steel sheet (about 0.20 in. under conditions existing in Germany) one should usually avoid clad metal fabrications.

Considering the guarantees for sound performance over long periods of time which appa-

Fig. 1 — Life of German High Speed Steels and of a Cemented Carbide at Different Machining Conditions*

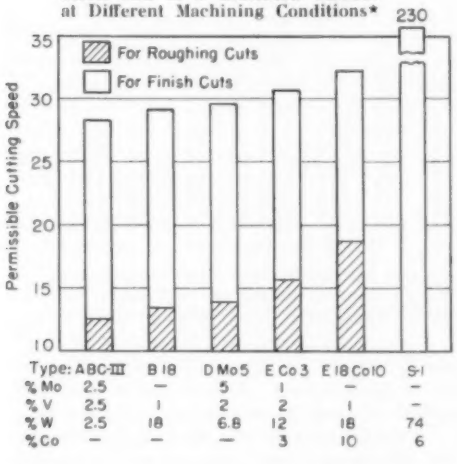
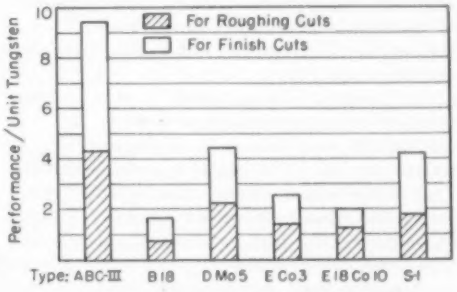

230
35
30
25
20
15
10
For Roughing Cuts
For Finish Cuts
Permissible Cutting Speed
Type: ABC-III B 18 D Mo 5 E Co 3 E 18 Co 10 S-1
% Mo 2.5 — 5 1 — —
% V 2.5 1 2 2 1 —
% W 2.5 18 6.8 12 18 74
% Co — — — 3 10 6

Fig. 2 — Performance of the High Speed Steels and the Cemented Carbide of Fig. 1 Related to the Unit of Tungsten Content



ratus manufacturers must sometimes grant, they are very reluctant to adopt any changes from a conservative design. Therefore, much depends on dependable design data established in joint cooperation and checked by the code authorities. This is true particularly for steam boilers and high-pressure containers which are held to strict specifications. Rules should be examined to find whether they do not specify unnecessarily high safety allowances and, therefore, heavier weights and higher contents of alloys than are justified, especially in a national emergency. Figure 3, for example, shows the substantially higher properties actually realized in four tube steels than those guaranteed and permitted by German boiler codes. It should be most helpful if the specifications in the countries participating in our conservation measures could be compared in the light of present experience.

A remarkable contribution to the conservation of metals important for national defense could be achieved by the processing firms with only a small amount of extra work if they would carefully separate the scrap produced in their

*_Finishing Conditions:_ Feed, 0.46 mm. (0.018 in.) per revolution; depth of chip, 2 mm. (0.079 in.); material cut, 0.60% carbon steel with tensile strength of 80 kg. per sq.mm. (113,000 psi.); clearance angle, 8°; front rake angle, 5°; nose angle, 90°; setting angle, 45°; angle of inclination, 10°; round-off radius of cutting edge, 2 mm. (0.079 in.).

Roughing Conditions: Feed, 1.10 mm. (0.043 in.) per revolution; depth of chip, 5 mm. (0.197 in.); material cut, 0.65% carbon steel with tensile strength of 90 to 93 kg. per sq.mm. (128,000 to 132,000 psi.); clearance angle, 8°; front rake angle, 10°; nose angle, 90°; setting angle, 45°; round-off radius of cutting edge, 2 mm. (0.079 in.).

fabrication shops into grades — or at least into groups — and send it back to the producers or to central collection depots. The alloys could be recovered from a large portion of the new scrap which otherwise would be lost in mixtures of unknown composition. A somewhat more expensive way is to melt this scrap without refining and to then determine its exact analysis. This procedure will be worth the trouble, doubtless, for the more expensive alloy elements such as molybdenum, nickel and tungsten, which do not readily enter the slag.

CONSERVATION IN STEEL PRODUCTION

It is not implied that users and processing firms should bear the brunt of emergency measures. The main burden rests upon the producers of the metals and alloys, who will be held mainly responsible for the maintenance of quality.

A material indispensable in the production of steel is manganese. Rich ore deposits are lacking in Western Europe as well as in North America. That is the reason why our countries are of one mind in using deoxidation and alloy agents, high in manganese, as sparingly as possible.

German blast furnace and steel plants may use, for the production of the various grades of pig iron and steel, only that manganese carrier with the lowest content of manganese which will yield the desired carbon and manganese in the finished product. For example, in smelting basic bessemer pig iron (the manganese content of which is about 0.6% in Germany) no ore is allowed to be used having more than about 2% of manganese. For deoxidation of conventional basic bessemer steel containing ordinarily more than 0.05% carbon and 0.3 to 0.8% manganese, and of openhearth steels having more than 0.12% carbon and a maximum of 0.6% manganese, only ferromanganese with a maximum of 45% Mn is allowed. A preliminary deoxidation is carried out with spiegel or with a blast furnace manganese-iron containing 20 to 30% manganese. Deoxidizing alloys should be added in the ladle rather than in the furnace, in order to keep the melting losses as low as possible and to obtain the highest benefit. The results of this mode of operation may be seen from Fig. 4. Experience during World War II showed that such a procedure does not impair quality.

In the steel plant a melting loss of more than 20 to 25% (with the exception of columbium, tantalum, titanium and, in certain circumstances, of vanadium) can be avoided by adequate furnace and slagging practice. For the recovery of chromium, which in the openhearth furnace oxidizes relatively easily, special slag reducing methods have been developed. At the end of the refining action, a more or less important part of the chromium has entered into the slag, whereupon calcium-silicon and ferrosilicon are added (and sometimes an additional amount of aluminum). This results in a white slag having a low content of carbide (similar to the familiar electric furnace slag) from which much chromium will be transferred back into the metallic bath. When using this method considerable amounts of high-phosphorus slags must be skimmed previously, which is a considerable physical strain on the furnace crew. But, we know of no better way to drive the most metal out of the slag.

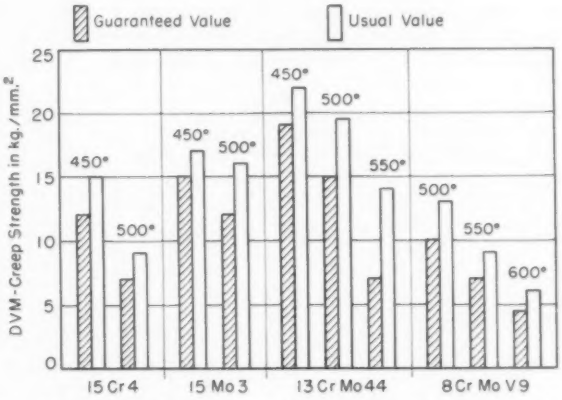


Fig. 3 — Relation Between the Guaranteed Value and the Most Frequent Value for Creep Limit of German Tube Steels Having High Strength at Elevated Temperatures

I should mention also the working of stainless chromium-nickel scrap with the oxygen lance in the electric furnace. We in Germany have taken over this method from the United States and from England, and are also able to recover the nickel almost completely and about 80 to 90% of the chromium. Figure 5 shows the lowered consumption of chromium and nickel for stainless steels since the use of this method in Germany. However, our reserves of scrap have almost been used up, therefore consumption of new nickel and chromium will necessarily increase.

One can also count on recovering consider-

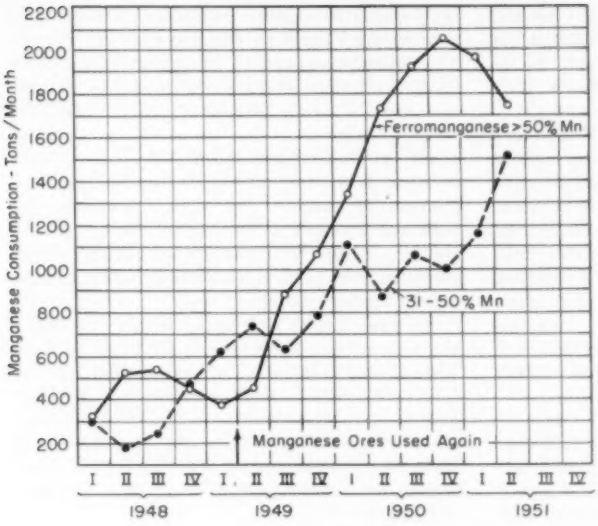


Fig. 4 — Quarterly Consumption of Manganese in Germany Shows the Influence of Expanding Steel Production Since 1948. Note reduction in amount of ferromanganese in relation to low-manganese deoxidizers since 1950

able vanadium from basic bessemer pig iron. Usually our basic pig made from Swedish, Minette or Salsgitter ores contains 0.09 to 0.15% vanadium. In the basic bessemer slags or in the roof dust of steel plants, this vanadium will be concentrated to 0.4 to 0.6%. During the war the German steel plants were required to deliver a certain amount of slag rich in vanadium irrespective of the loss encountered in the production. In order to minimize converter losses, we are now endeavoring to obtain preliminary refining slags with 2 to 4% vanadium in the blast furnace trough or in ladle-like vessels by blowing in hot air or oxygen. The cost of such vanadium is obviously much higher than the present price from commercial ores. Since, however, vanadium may often be used as a substitute for tungsten or molybdenum, this expense may be justified — especially if the shortage of alloying elements is sufficiently acute.

SUBSTITUTION OF ALLOYS LOW IN STRATEGIC METALS

This leads us to the problem of switching over to new materials. I want to give you a general survey of this matter, based on our tests and experience with steel as well as with nonferrous metals.

Cobalt — For permanent magnet materials, high speed steels, wear resisting weld deposits and cemented carbide alloys, cobalt is playing an important role. It can be dispensed with only rarely without impairment in quality. With cemented carbide tools, for instance, experiments with nickel as a binder clearly show a decrease in performance.

Molybdenum covers a much more extended field of application. Metallurgists in the United States, where the major part of the molybdenum is produced, were the first to discover its favorable effects on steel and iron and have fostered its diversified use, primarily by a wise price policy. Molybdenum can be replaced by tungsten in high speed steels, but usually it is more desirable to conserve tungsten than it is to conserve molybdenum. Replacement of molybdenum by vanadium alone or in combination with chromium or aluminum is not possible — at least at present. On the other hand, a very useful

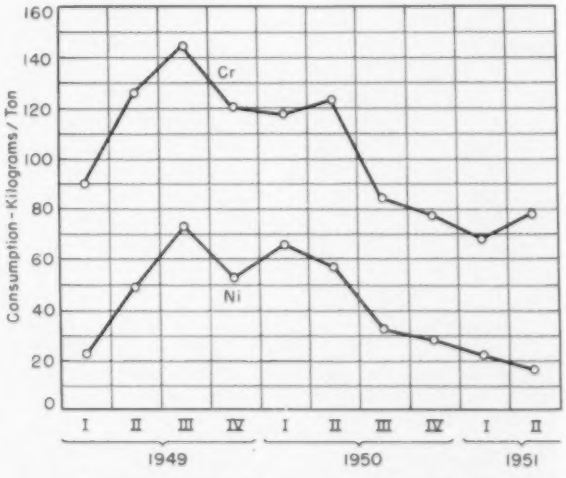


Fig. 5 — Quarterly Consumption of New Chromium and Nickel for German Stainless Steels. Note reduction since mid-1949, when oxygen has been used to aid in recovery of alloy from return scrap

high speed steel, low in strategic alloy constituents, is made with an intelligent balance of molybdenum, tungsten and vanadium, as is proven by experience with the ABC-III steel noted in Fig. 1.

In steels having high strength at elevated temperatures, molybdenum cannot be dispensed with. A saving in this field can be achieved with best results by replacing part of the molybdenum with vanadium; this requires higher heat treating temperatures and results in higher scaling and distortion during heat treatment. Considering the present state of our knowledge, a substitution should not be recommended in heavy forgings, such as shafting and rotors for steam turbines, which must be stress relieved by slow cooling yet must not suffer from temper brittleness.

In the conventional heat treating and case hardening steels, molybdenum could be used only for especially important parts — and even less molybdenum will be needed if boron is properly used. American developments in this field have been confirmed in Germany.

For molybdenum in stainless steels no adequate substitute is available. Sometimes it may be possible to replace stainless steels by 16% silicon cast iron or by ceramic bodies.

Columbium exerts a unique effect upon the creep strength of alloys which cannot be attained by other alloying elements. It is, however, largely replaceable by titanium in stainless steels, in which the greatest part of it appears to have been used up to the present for the fixation of carbon. In many instances, by sufficiently reducing the carbon content of the stainless alloy, the troublesome intergranular corrosion can be avoided without adding either columbium or titanium.

Nickel can be eliminated in case hardened and heat treated steels with small cross sections without any difficulty, or its content can at least be lowered to such an extent that sufficient may be recovered from the scrap. With heavier sections, however, the favorable deep hardening effect of nickel cannot be obtained in the same degree by other elements — as, for instance, manganese.

In stainless steels the austenite-forming elements, manganese and nitrogen, are not equivalent to nickel. Savings in nickel may often be

1800-Ton Hydraulic Press at Bofors Forge Plant in Sweden

obtained by using stainless irons or steels without nickel or with a greatly reduced nickel content, provided that the corrosion conditions are not too severe. Processing of these substitute steels will generally be more difficult.*

CONSERVATION AND REPLACEMENT OF NONFERROUS METALS

In the field of nonferrous metals, much experience has been gained in Germany, though such experience has been dearly bought. Affected by fashion, the consumer is accustomed to demand quite a luxurious surface appearance on his devices, which accounts for the big consumption of nickel and chromium-plated parts in motor cars, bicycles, refrigerators, and so on. And yet copper, nickel and chromium are scarce all over the world! Without being deprived of a silver or chromium-like luster, the consumer could save these valuable materials if he used chemically polished and electrolytically brightened pure aluminum (99.998%) obtained from ordinary aluminum scrap by three-layer electrolysis and hardened by certain alloy additions.

What has been said regarding the sorting of steel scrap is valid to an even greater extent for nonferrous metals. Painstaking sorting by modern electric conductivity apparatus is of as great importance as the metallurgical processes themselves. In general, the best over-all results will be obtained by a systematic regeneration of the metal waste — that is to say, scrap refining. This applies to light metal waste of all types as well as to heavy metal waste, including ashes and dross. In this way it is possible to produce high-quality secondary metals, meeting the standard specifications, from scrap. Pure magnesium can be distilled from "electron" scrap (magnesium-aluminum alloy). Zinc scrap can be transformed in a simple and effective manner into high-quality zinc alloys.

In all countries almost half of the copper is consumed by the electrical industry. In high-tension power lines and most of the electrical lines down to the house connection, copper can be replaced by aluminum. Contrasted to this, the replacement of electric wires inside houses, including telephone and telegraph wires, is not advisable. For these, copper should be used. Neither should important armatures, now made of copper, be made of aluminum or zinc.

As regards lead, we can see that today cable coverings can be replaced by plastics or light metal alloys. Even lead paints can largely be replaced by other paints or varnishes. In the construction of apparatus we find today much aluminum and plastics in place of lead. In storage batteries, however, it cannot be dispensed with as yet.

Zinc can be saved partly by substituting light metals for zinc alloys, including brass, and substitutes for most zinc paints are available. For zinc sheets different possibilities of replacement are available. More difficult, however, is a substitution for galvanized steel parts; some economy is possible by using a thinner electroplated coating. If zinc is in very short supply, paints or lacquers may serve for many galvanized parts, even though the latter would have a longer life.

Much tin can also be replaced, as shown by experience in World War II, by synthetic resin varnishes, plastics or by light metal alloys. It cannot be completely replaced, however, in solders and bearing metals.

DESIRABILITY FOR COOPERATION AND RESEARCH

I know that you all realize that what I have said represents merely a few high spots of a most complex situation. The scarcity problems are different in different countries. They may be different for different companies or different industries within the same country. Often there are two or more solutions and a choice is possible. Perhaps if one country chooses one solution more or less automatically, another country may be compelled to use another. Also each problem must be explored from many, many angles.

Since we are talking about substitutes, of this we may be certain: There is no substitute for hard work, clear thinking, courageous acting, and wholehearted cooperation where scarcities are involved. And speaking of cooperation, with the vast experience of the Free Countries, their tremendous raw material resources, their unsurpassed technology, their genius for invention and research, only the will to cooperate and a suitable interchange of information are needed to make certain beyond any possible doubt that the metals known to be available will be so used as to permit the Free World to remain free.

*EDITOR'S FOOTNOTE — In the conferences between American and Overseas Conferees during the World Metallurgical Congress, it was stated that stainless steels wherein manganese replaced much of the nickel were of a distinctly reddish color and were unsuitable for decorative purposes and even rejected by chemical equipment manufacturers for that reason. It was also brought out that the workability and formability of the high chromium-irons being substituted for 18-8 were directly proportional to the amount of reduction between slab and finished sheet.

Transformation of Low-Carbon, 12% Chromium Stainless Steels

By A. E. Nehrenberg
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Crucible Steel Co. of America
Spaulding Works, Harrison, N. J.

SINCE THE PIONEERING WORK of Davenport and Bain on isothermal transformation of steel much attention has been devoted to the metallography and transformation characteristics of many different steels. As a result, the structural changes and transformation behavior during heat treatment of most commercial steels are quite thoroughly understood.

The low-carbon, 12% chromium stainless steels have been a notable exception, however, and this investigation was undertaken early in 1951 to provide data not then available on the metallography and transformation characteristics of these steels. In order that the study would cover most of the variations likely to be encountered in practice, heats of low, intermediate and high attainable hardness were included. Their analyses are given on p. 66.

These steels were obtained as $\frac{7}{16}$-in. square bars, hot rolled from regular commercial heats. The bars were annealed in the laboratory by heating 1 hr. at 1800° F., followed by a furnace cool to 1300° F., and holding there overnight.

Austenite Formation — The A_1 temperature was determined by heating samples for 1 hr. at various temperatures, quenching, and examining them metallographically for evidence of the presence of austenite at the heating temperature. It was found that A_1 for all of the steels was 1480° F.

A series of photomicrographs that illustrate the progress of austenite formation in the 0.06 and the 0.12% carbon steels are shown in Fig. 1. In both steels the amount of austenite increases with increasing temperature above A_1 up to about 1700° F., whereupon the maximum amount possible has been formed. The 0.12% carbon steel is fully austenitized (except for some undissolved carbide) at 1700° F., whereas the 0.06% carbon steel contains about 9% ferrite.

Figure 2 shows that for both the 0.06 and the 0.10% carbon steels the amount of ferrite is constant for the temperature range 1700 to 2000° F. At 2100° F. and above there is more ferrite present in these steels than in the above range, and the amount increases with further increase in temperature. Between 2475° F. and the solidus, 2650° F., the 0.06% carbon steel consists only of ferrite. It is necessary to heat the 0.10% carbon steel to 2500° F. to obtain a completely ferritic structure.

In the 0.12% carbon steel no ferrite was

Steel: 0.06% C., 12.8% Cr

1500° F. 1600° F. 1700° F.

present at any temperature between 1700 and 2100° F. At 2200°, traces of ferrite were observed, and the amount of ferrite increased with temperature up to 2525° F., and from there to 2600° this steel is completely ferritic.

The solidus temperatures for these steels were found to vary from 2600 to 2650° F., depending upon the carbon content. For the 0.06% carbon steel the solidus is 2650° F.; it is 2600° F. for the 0.12% carbon steel.

According to the carbon-chromium-iron constitutional diagram given in the 1948 edition of the A.S.M. "Metals Handbook", p. 1249, the 13% Cr, 87% Fe alloy containing 0.10% carbon should be completely ferritic at temperatures above 2300° F., but the data in Fig. 2 show that it is necessary to heat commercial stainless steels of approximately that carbon and chromium content to temperatures ranging from 2475 to 2525° F. to produce 100% ferrite. Bloom and his associates have also shown in an article in *Metal Progress* for February 1951 that the boundaries of the gamma loop in the 0.1% carbon section, particularly at the higher temperatures, must be shifted if they are to conform with data obtained on commercial materials.

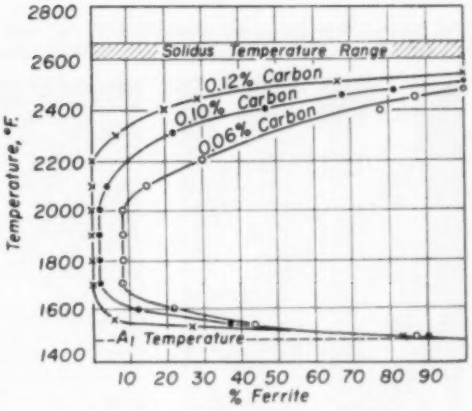


Fig. 2 — Effect of Temperature and Carbon Content on the Amount of Ferrite in 12.5% Cr Stainless at Elevated Temperatures

AUSTENITE FORMATION

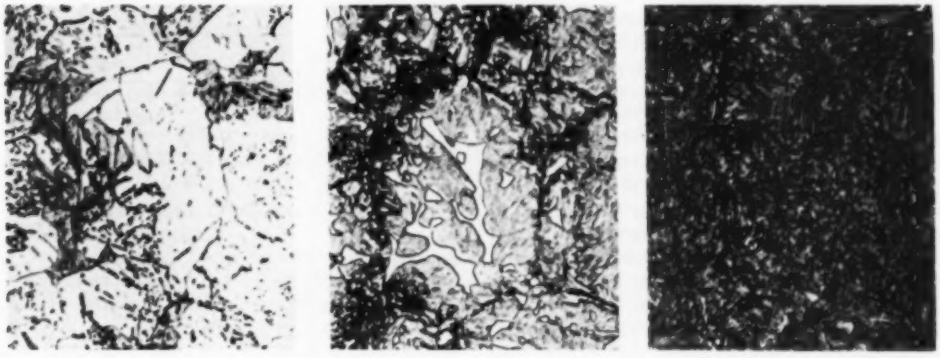
During Quench — We could not quench specimens rapidly enough from 2400° F. or higher to avoid forming some austenite during cooling. Some difficulty was encountered in the interpretation of the microstructures, until we could distinguish the areas which transformed to austenite *during* the quench from those which were austenite *at* the high temperature. (By the time room temperature is reached in the cooling cycle the austenite which was present at higher temperatures, and that which formed during cooling through the high temperature region, had been transformed to martensite.)

Figure 3*a* shows the above differentiation after the specimen had been tempered 1 min. at 1050° F. to darken the martensite. Note the difference between the kernels of the grains and their sheaths; the latter represent austenite which transformed during the brine quench.

When the structure is entirely ferritic at the high temperature, as the 0.06% carbon steel

Fig. 1 — Progress of Austenite Formation in 12.5% Chromium Steels Containing 0.06 and 0.12% Carbon. Dark-etching structure (tempered martensite) was austenite at time of quench. Magnification 600×. Etched in mixture of 5 g. picric acid in 100 cu.cm. ethyl alcohol to which is added 10 cu.cm. of "Zephiran chloride" (a product of Winthrop-Stearns, Inc., of New York City, which is an aqueous solution of 12.8% benzalkonium chloride) to increase contrast

Steel: 0.12% C, 12.3% Cr



1500° F. 1600° F. 1700° F.

(a) $\frac{1}{16}$-In. Disk Quenched From 2400° F. Magnification 175×

(b) $\frac{1}{16}$-In. Disk Quenched From 2500° F. Magnification 75×

(c) $\frac{1}{16}$-In. Disk Quenched From 2500° F. Magnification 75×

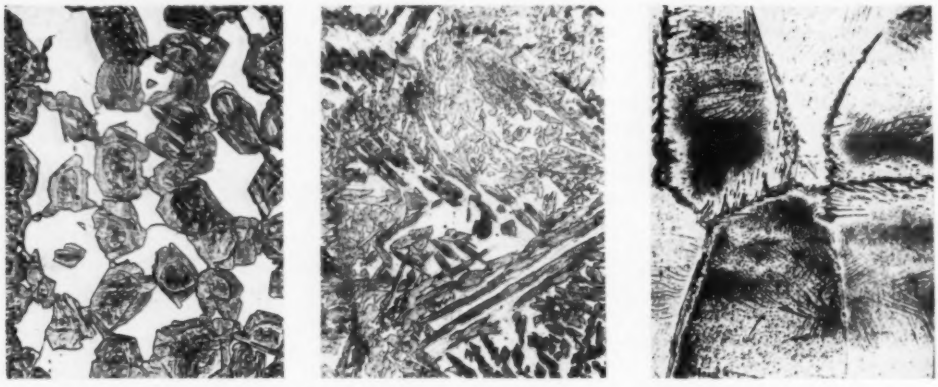


Fig. 3 — Austenite Formation in 0.06% C, 12.8% Cr Steel During Iced Brine Quench From High Temperatures. Samples were tempered 1 min. at 1050° F. to darken martensite areas. The cores of the martensite in *(a)* denote areas that were austenite at 2400° F.; the lighter-etching periphery is the result of austenite formation during the quench. The tempered martensite in *(b)* and *(c)* indicates austenite that formed during the quenching of a structure which was originally 100% ferrite

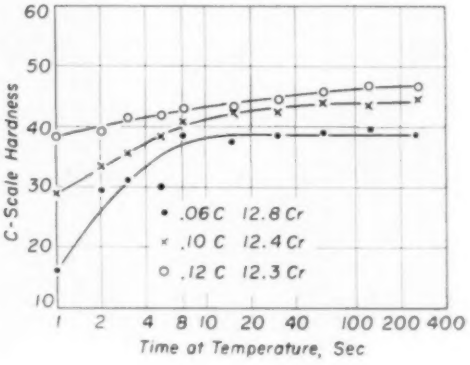
at 2475 to 2650° F., the austenite that forms *during* the quench appears at the ferrite grain boundaries and along definite planes of the ferrite, as shown in Fig. 3*b*. Investigators have observed this structure in chromium alloys since 1930 and attributed it to the transformation of delta ferrite to austenite during the quench.

In an attempt to minimize this reaction, the sample was reduced from $\frac{3}{16}$ to $\frac{1}{16}$ in. thick, so as to speed up the rate of cooling sufficiently. This reduced the amount of the ferrite-to-austenite transformation considerably, as Fig. 3*c* shows, but even now some formed in the vicinity of the ferrite grain boundaries. (The 1-min. temper at 1050° F., to darken the martensite, also precipitated carbides along strain lines in the ferrite.)

Grain Size at High Temperatures — In examining small samples of the 0.12% carbon steel heated to various temperatures and quenched, it was observed that the grain size at 2300 was much finer than that at 2100° F. When this steel is heated quickly to 2300° F. there is not enough time for it to become completely austenitic while it is in the 1700 to 2100° region, and the ferrite which remains retards grain growth. Thus, when such a sample is heated rapidly to 2300° F. (where it should be 10% ferrite, according to Fig. 2) and held there for 15 min. before water quenching, the result is a fine-grained martensitic background which contains numerous small grains of ferrite. Its original structure did not have time to equalize at 100% austenite during heating. If a similar sample were heated to 2100° F. and held there 15 min., there is time for complete austenitization and growth of austenite grains. When the latter is heated farther into the region where austenite transforms into ferrite, held briefly (2300° F. for 15 min.) and then quenched, the very large austenite grains are outlined by ferrite.

Effect on Hardness — Our data on the effect of austenitizing temperature on the hardness of 12.5% chromium steels are in agreement with those recently acquired by Rickett and his co-workers (Preprint No. 17, October 1951 meeting). In general, the hardness after a

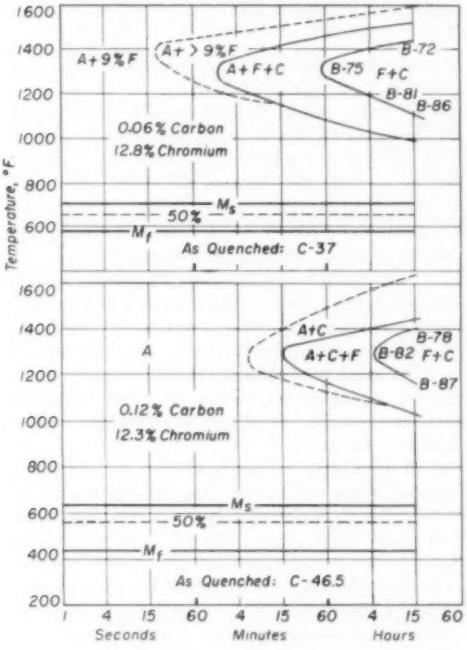
Fig. 4 — Effect of Time at 1800° F. on Hardness of 12.5% Chromium Steels. Prior condition — annealed



quench increases with increasing temperature above the A_1, reaches a maximum value, and finally decreases with a further increase in temperature because of the growing amount of ferrite in the high-temperature region.

For our 0.06% carbon steel the maximum hardness, Rockwell C-37, was obtained by a quench from any temperature within the range of 1700 to 2000° F. This corresponds exactly with the range for maximum austenite (Fig. 2) in this steel. For our 0.10 and 0.12% carbon steels the range of austenitizing temperature for maximum hardness is 1800 to 2100° F. These hardnesses are Rockwell C-43.5 and 46.5 respectively. A higher minimum austenitizing temperature than shown in Fig. 2 is required for these higher carbon steels to obtain complete solution of the carbides.

Fig. 5*a* (Above) — TTT-Diagram for 0.06% Carbon, 12.8% Chromium Steel. Fig. 5*b* (Below) — TTT-Diagram for 0.12% Carbon, 12.3% Chromium Steel. All samples austenitized 1 hr. at 1800° F.



The above hardness data were all obtained on samples heated for 1 hr. at various temperatures. Much less time is required for equilibrium to be established above 1800° F.

In Fig. 4 the effect of time at 1800° F. on the hardness of the 12.5% chromium steels is shown. The data were obtained by heating specimens 0.060 in. thick in a lead bath at 1800° F., holding them for various times, and water quenching.

Table I — Analyses of the Steels

Element	Attainable Hardness		
	Low	Intermediate	High
Carbon	0.06	0.10	0.12
Manganese	0.56	0.48	0.47
Phosphorus	0.020	0.021	0.017
Sulphur	0.026	0.033	0.018
Silicon	0.25	0.30	0.39
Nickel	0.19	0.36	0.35
Chromium	12.78	12.43	12.30
Molybdenum	0.02	0.47	0.29
Copper	0.10	0.14	0.11
Aluminum	0.013	0.015	0.016
Nitrogen	0.033	0.032	0.037

The soaking time for maximum hardness varies with carbon content. For the 0.06% carbon steel it is only about 10 sec. For the 0.10 to 0.12% carbon steels, the time necessary for maximum hardness is increased to 1 min. and 2 min., respectively. (These figures apply only when fully annealed material is heated; martensitic samples acquired full hardness in 3 sec. or less at 1800° F.)

TRANSFORMATION CHARACTERISTICS

Two representative TTT-diagrams determined by conventional metallographic procedures are shown in Fig. 5. The 0.06% C, 12.8% Cr steel behaves like a hypo-eutectoid steel at the higher temperatures in the "pearlite" region, in that the separation of ferrite precedes the formation of an aggregate of ferrite and carbide. In the ensuing discussion this ferrite will be called "pro-eutectoid ferrite". In the 0.12% C, 12.3% Cr steel the precipitation of grain boundary carbide precedes the formation of the ferrite-carbide aggregate. Hence, this steel may be considered to be hyper-eutectoid.

The diagrams of Fig. 5 are similar in their essential features to those recently presented by Rickett and his associates. The only real difference is in the lines which denote the separation of the pro-eutectoid constituent, and this is mainly of academic interest and has already been commented upon by the present author in his discussion of Rickett's paper.

When formed at 1400° F. or below, the pro-eutectoid ferrite has a composition different from that of the ferrite which existed at the

(*a*) — 4 Min. at 1400° F.; Quenched; Tempered 2 Min. at 1050° F.; Water Quenched; Tempered 2 Min. at 1050° F. heated 30 Min. at 1450° F.

(*b*) — 4 Min. at 1400° F.; 30 Min. at 1450° F.; Water

(*c*) — 2 Hr. at 1400° F.; Water Quenched; Tempered 30 Min. at 1450° F.

(*d*) — 4 Hr. at 1400° F.; Water Quenched; Tempered 30 Min. at 1450° F.

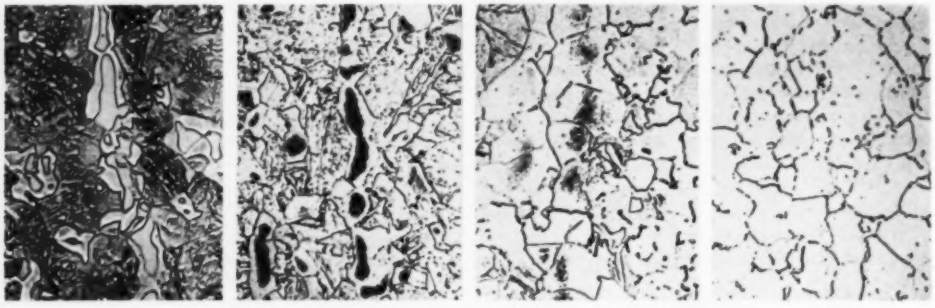


Fig. 6 — Decrease in Carbon Content of Delta Ferrite in 0.06% C, 12.8% Cr Steel During Transformation at 1400° F. Samples were austenitized 1 hr. at 1800° F., then subsequently treated as indicated above. Magnified 400 diameters. Etchants: (*a*) Zephiran chloride – picral; others, Allten's reagent (250 cu.cm. ethyl alcohol, 225 cu.cm. lactic acid, 35 g. tartaric acid, 50 cu.cm. concentrated hydrochloric acid, the mixture was used electrolytically at 6 volts with the specimen employed as the anode)

austenitizing temperature. It will be convenient in the ensuing discussion to refer to the latter as "delta ferrite". These ferrites can be distinguished by metallographic means, as Fig. 6*a* illustrates. When that same sample was tempered at 1450° F. for 30 min. it appeared as in Fig. 6*b*. Precipitated carbides are now present in the areas that were delta ferrite, but none are in those that were pro-eutectoid ferrite. Evidently, delta ferrite contains more carbon.

As the transformation is allowed to proceed at 1400° F., the carbon content of the delta ferrite grains decreases by diffusion to the grain boundaries. By the time the transformation is complete the two ferrites are indistinguishable. This is illustrated by Fig. 6c and 6*d*. Figure 6c represents a sample about 85% transformed at 1400° F., quenched, and tempered at 1450° F. for 30 min.; the amount of carbide precipitated in the delta ferrite is much less than it was in the sample transformed 4 min. at 1400° F. shown in Fig. 6*b*. Figure 6*d* shows that precipitation no longer occurs in areas that were formerly delta ferrite when a sample completely transformed at 1400° F. is tempered.

The carbon content of the delta ferrite decreases with time at transformation temperature, not only at 1400° F., but at all temperatures between 1100 and 1400°. As a result, it is impossible to precipitate carbides in the delta ferrite by tempering when the transformation has been completed at any temperature in the pearlite region.

It should be emphasized that precipitation was not observed in the delta ferrite of any of the *austenitized* samples held for various times between 1100 and 1500° F. before being quenched. Precipitation occurred only during *reheating* at 1300 to 1500° F. of samples incompletely transformed in the pearlite region, or in those fully hardened and then tempered at these temperatures.

Micrographs illustrating precipitation in delta ferrite during tempering after hardening are contained in Rickett's ⊖ paper. If a tempered sample containing carbides in the delta ferrite is heated 50° or so above the A_1 temperature, the carbides disappear, and the ferrite becomes light-etching. This is illustrated by Fig. 7 which shows the effect of reheating (at 1540° F. for 1 hr.) delta ferrite which contained

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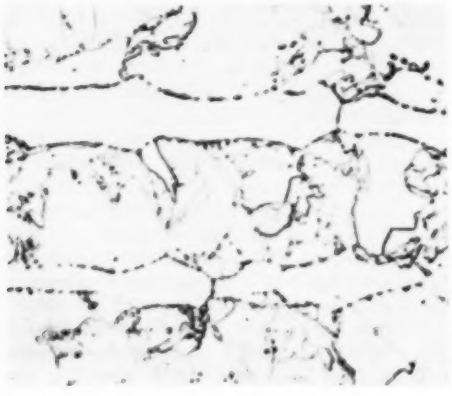
Fig. 7 — Effect of Reheating Delta Ferrite Containing Precipitated Carbides to 1540° F. Magnification 1500×. Etched in Allten's reagent



A Metallurgist Looks at Fracture

A briefed presentation of the 26th Edward deMille Campbell Memorial Lecture, October 17, 1951.

By C. H. Lorig
Assistant Director
Battelle Memorial Institute
Columbus, Ohio

IT IS NOT NEWS TO YOU, who are metallurgists, that metals are neither homogeneous nor isotropic, with equal physical properties in all directions. In fact, they are not uniform in composition and structure and they are anisotropic — their properties are different with differences in direction and with sign of stress.

It is also no news to you that most of our current theories of flow and fracture of metals are based on assumptions that metals are homogeneous and isotropic. If we are to improve the physicists' predictions we must use a clearer picture of the fundamental nature of metals.

The engineer is awaiting this clearer picture. The problems linked with fracture are of great importance to him. He is constantly concerned with metals which must support loads without appreciable flow — and certainly without fracture. He must use the right metal in the right spot and he needs to know more about the circumstances that determine fracture.

Two decidedly different approaches have been taken in the development of our present theories of the behavior of metals under stress. In one, we have aimed to link up atomic structure with metal behavior; in the other, we have formulated theories regarding metal behavior from empirical mathematical relationships which idealize the observations we have made about metals.

There are a number of theories concerning the ability of a material to resist flow and fracture, but none of these apply universally. Designers

Lecture continues overleaf →

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precipitated carbides. Carbides formerly in the delta ferrite have disappeared; simultaneously numerous carbides appear in the ferrite grain boundaries. The carbides in the tempered delta ferrite were not simply redissolved in this ferrite at 1540° F. and retained in solid solution, for they could not be reprecipitated by a subsequent temper at the temperature at which they formed originally.

The variation of microstructure with transformation temperature has been well illustrated with Rickett's micrographs.

SUMMARY

Quantitative data have been presented to show the variation in amount of delta ferrite with temperature in 12.5% chromium stainless steels containing 0.06, 0.10 and 0.12% carbon. Between 1480° F. (the A_1 temperature) and 1700° F., the amount of austenite increases with increasing temperature. In the range from 1700 to 2000° F. the amount of austenite is constant at the maximum possible value; conversely, the amount of delta ferrite is a minimum. The 0.12% carbon steel contained no delta ferrite at 1700 to 2000° F., whereas the other two steels contained 9% and 2% ferrite, respectively. Temperatures of 2475 to 2525° F., depending upon the carbon content, were required to produce a completely ferritic microstructure in these steels. The solidus temperature was found to decrease from 2650 to 2600° F. with increase in carbon from 0.06 to 0.12%.

Isothermal transformation diagrams show that in a 0.06% C, 12.8% Cr steel pro-eutectoid ferrite forms before the ferrite-carbide aggregate at the higher temperatures in the "pearlite" region. In the higher carbon steel (0.12% C, 12.3% Cr), pro-eutectoid carbide precipitates at the austenite grain boundaries prior to the formation of the aggregate.

When formed at 1400° F. and below, the pro-eutectoid ferrite is of lower carbon content than the delta ferrite present at the austenitizing temperature. This is shown by the fact that carbides can be precipitated in delta ferrite, and not in the pro-eutectoid ferrite, when samples are incompletely transformed at 1400° F. or below. This precipitation requires a reheating at 1300 to 1500° F. The carbon content of the delta ferrite decreases as transformation proceeds in the "pearlite" region, with the result that carbides cannot be precipitated in the delta ferrite after the transformation has been completed at any temperature in this range.

and engineers have a satisfactory basis of design for parts and structures working under simple systems of stress. They can design for ductile materials; they can also design for brittle materials. They do not have, however, a sound basis of design for materials such as ship plate, which are nominally ductile, when they behave in a brittle manner. Here the safe load limit is governed not by plastic flow but by unpredictable fracture. Unpredictable fracture gives none of the danger signals that always appear when materials behave in a ductile manner prior to such fracture. For that reason, we need to perfect our understanding of fracture so that the brittle type of failure in ductile metals can also be predicted.

I shall discuss the fracture aspect of metal behavior mainly from the point of view of the metallurgist. What does the metallurgist see through his microscope? If metals are not homogeneous, what is their nature?

We know a few facts, at least. The microscope shows us clearly that metals are heterogeneous: they consist of vast aggregates of crystals in which there are grain boundaries, segregations of impurities, internal defects and, often, dissimilar phases. The very nature of metals introduces many opportunities for anisotropic behavior in fracturing.

The original theory of flow of metals, offered 52 years ago by Ewing and Rosenhain, in which they conceived that slip occurred along glide planes of the crystalline grains, was based on the assumption of anisotropy. But any inclusive theory of metal behavior must also deal with the effects of certain microstructural features on the properties. These features are equally as important as are atomic and other fine-scale phenomena. If we want to bridge the gap between what we know and what we do not know about metal behavior, all of these phenomena must dovetail into the picture.

It becomes important, then, to recognize that microstructural heterogeneity in metals is responsible for *several* kinds of processes, either singly or in combination, that may lead to fracture. Let us consider some of the work done on this. The first citation is a general one showing that fracture is closely related to the structure we see through the microscope.

Wells and Mehl investigated something long known to forgemen: Tensile tests from even the highest quality gun steels, which generally broke with a cup and cone fracture, occasionally displayed an angular fracture. They concluded that the occurrence of angular fracture depended largely on the orientation of the

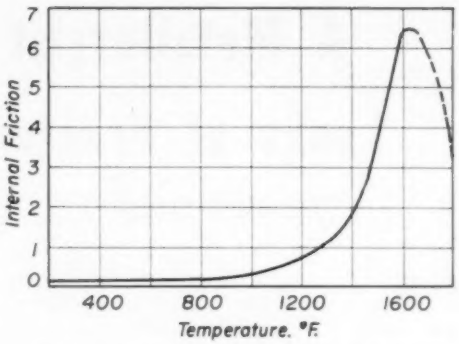


Fig. 1 — Value of Internal Friction in Molybdenum During Torsional Oscillation Depends Upon the Temperature. Location of peak of curve varies with frequency of oscillation

dendritic pattern in the structure of the steels. By using specimens with different angles between the longitudinal axis and the flowline direction they found that neither the tensile nor the yield strength was "structure sensitive" — that is, these properties were independent of flowline direction. However, ductility (which they expressed in reduction of area values) was sensitive to variations in structure. Average variations in reduction of area were quite small for small angles but became very large when the angles exceeded 50°.

Because tensile and yield strengths are not sensitive to directionality, we can interpret the results to mean that the steels were isotropic with respect to flow stress. On the other hand, because the ductility was sensitive to flowline directionality, the steels are anisotropic with respect to fracture stress.

This is a general example. We can now give several examples where fracture is related to specific structural features in metals. Only a few earlier investigations focussed attention on the microstructural features of fracture behavior, but metallurgists have paid some attention to the part played by grain boundaries. Their importance is nicely illustrated by the behavior of carbon steels and low-alloy steels under loads at elevated temperatures. Below a certain "softening" temperature,* characteristic of such steels, grain boundaries tend to act as

*Editor's Note — The term "equi-cohesive" temperature was adopted by Jeffries and Archer in "The Science of Metals" (1924) to denote the temperature where the grain-boundary material and the grain itself are equal in strength. Hereafter the term without quotation marks has this specific meaning.

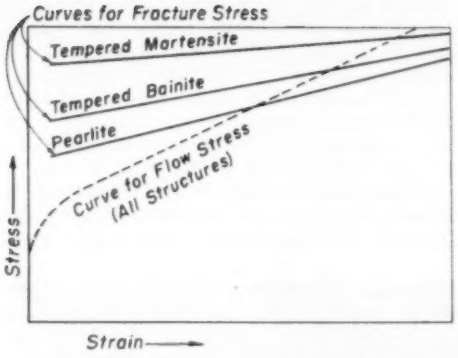


Fig. 2 — Superimposed Fracture-Stress Curves for Steels With Different Microstructures but Having Similar Flow-Stress Curves. The fracture stress of tempered martensite is highest, bainite is intermediate, pearlite is lowest

strong rigid material and fracture occurs through the crystals regardless of the rate of strain. But above this softening temperature, grain boundaries show all the characteristics of a viscous material and fracture, occurring through them, becomes intergranular.

The viscous character of grain boundaries in metals at elevated temperatures is strikingly demonstrated by the decay of torsional oscillations in internal friction tests. When such tests are made over a range of temperature, the results can be plotted as a curve like the one shown in Fig. 1, obtained at Battelle Memorial Institute on molybdenum, annealed 1 hr. at 4100° F. The peak in the curve in the neighborhood of 1600° F. can be interpreted in terms of the softening temperature. At this temperature the shear stress relaxes during each oscillation, but not completely, so that there is some dissipation of energy. This accounts for the high internal friction. The softening temperature shifts to lower or higher values with lower or higher frequencies of oscillation.

An important factor in the behavior of metal in the region of the softening temperature is, therefore, the *rate* of strain. Other investigators have found that at high strain rates the grains elongate, and fracture occurs on planes through the crystals and is, therefore, transgranular. At low strain rates, recrystallization of the metal and relaxation of shear stresses across grain boundaries tend to keep pace with the rate of strain. When that happens, the grains do not elongate, and fracture becomes intergranular, since it occurs by separations on surfaces of the grains.

In 1948, Zener described the conditions which lead to cracking when grain boundaries behave in a viscous manner. He pointed out that as the shear stress across grain boundaries relaxes, the corners where three grains meet become sites for an intense concentration of hydrostatic tension (that is, simultaneous tension in all directions). These tensions are not relieved by plastic deformation, but increase as the shear stress across grain boundaries continues to relax. Finally, the theoretical fracture stress is reached and cracking follows.

Some 15 years ago Chalmers studied certain aspects of this important problem and attempted to correlate the properties of grain boundaries with the interaction between neighboring grains. He determined the variations of the yield stress in tension for specimens of tin containing only two crystals but of different orientations. The boundary between the crystals was longitudinal and contained the axis of the specimen; growth of the crystals was so controlled that, at their boundary, one crystal was the mirror image of the other — that is, if we took one crystal and rotated it through an angle ϕ about the specimen axis, it would bring it into coincidence with the other crystal.

On testing a number of specimens covering a wide range of values for ϕ, Chalmers found that the yield stress increased linearly with the angle, becoming a maximum at 90°. This maximum value was approximately 60% more than the value obtained on a single crystal of tin oriented similarly to the stress. He concluded that the change in yield stress observed in the bi-crystal could not be attributed directly to the mutual grain boundary, but must come from the mutual interference of the grains because of their orientation.

I remarked earlier that gun steels could be regarded as anisotropic from the standpoint of fracture stress and isotropic from the standpoint of flow stress. A somewhat analogous situation was described in 1946 by Hollomon, who compared the fracture-stress curves of a group of steels having different structures but similar flow-stress curves. He summarized his results by superimposing the curves on the same graph (Fig. 2) which shows that after the first small amount of strain, the fracture stress of tempered martensitic steels is highest, that of bainitic steels is intermediate, and that of pearlitic steels is lowest.

This suggests that metals with structures comprising two or more metallographic constituents must be anisotropic and that they are capable of having more than one value of frac-

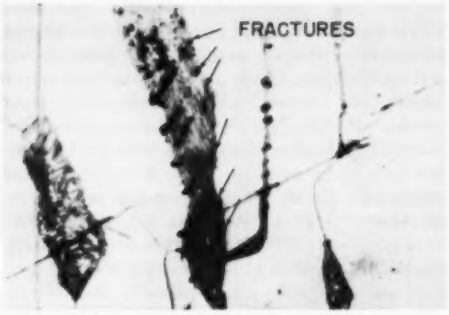


Fig. 3 — Microcracks in Carbide Lamellae Following Stress by Tensile Impact. (W. H. Bruckner)

ture strength. Fracture should start at the point in the metal where the fracture strength is first exceeded by the normal stress. Conceivably, this could be either at a grain boundary, at a defect, within any of the microconstituents, or along an interface of a microconstituent. Clearly there is no single unique fracture strength for a metal.

The recent work by Bruckner, at the University of Illinois, on the micromechanism of fracture in rimmed, semikilled, and killed steels shows that fracture can originate within a metal when the fracture strength of a constituent is exceeded. The process of fracture in pearlite under tensile impact began in one or more of the carbide lamellae, as illustrated by the dark parallel markings in Fig. 3. These tiny cracks may be linked by propagation through the intervening ferrite plates until the fracture traverses a portion or all of the pearlite grain.

Bruckner also observed microfractures in the carbide which partially outlined some of the ferrite grains. The fractures appear as dark markings crossing the carbides, as shown in Fig. 4. The tiny cracks tend to parallel one another in a direction about 45° to the direction of the maximum stress. Ultimately the microcracks may extend into the ferrite matrix to influence the fracture behavior of the steels.

All these studies make it clear that it is important to consider metals as heterogeneous when predicting fracture. The grain boundaries, the segregation of impurities, internal defects, and dissimilar phases open up many opportunities for anisotropic behavior. If we accept the premise that fracture in metals and alloys must follow discontinuities in the structure, then there are six possible paths along which fractures can proceed. They are:

1. Along grain boundaries.
2. Along boundaries between dissimilar phases.
3. Across grains of the matrix on preferred planes.
4. Across a compound or minor phase on preferred planes.
5. Along flaws in the metal aggregate.
6. Combinations of the above.

Those assumed paths of fracture agree with the common practice of classifying "completely ductile fractures" in metals as shear, and "completely brittle fractures" as either intergranular or transgranular. Here it is necessary to caution against the tendency to classify fractures from their general appearance alone. A similarity of appearance does not necessarily indicate similarity of origin. Fractures of different origin start by different mechanisms. Once started, they can propagate in much the same manner so that their over-all appearance may seem similar.

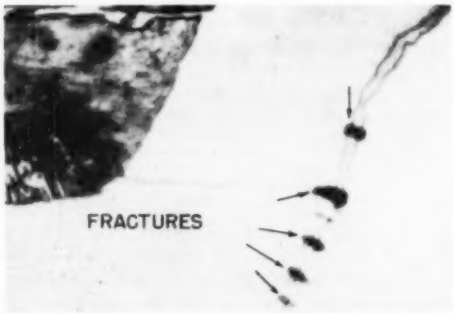


Fig. 4 — Microcracks in Carbide Films Outlining Ferrite Grains Tend to Be Parallel at About 45° to Direction of Maximum Stress. (W. H. Bruckner)

Fracture appearance, alone, can therefore be misleading. From what we know about fractures, it would seem better if we classified them from the standpoint of their origin *as well as* appearance.

Let us look a bit closer at the origin and paths of fracture observed in metals.

We know that below their softening temperature, pure (single phase) metals fracture rarely, if ever, along grain boundaries. In fact, the cohesive or fracture strength across grain boundaries is thought to be so much higher than the strength across preferred planes that fracture always begins within the grains. But many commercial metals, below their softening temperature, fracture in grain boundary regions. Such fractures are classified as intergranular. A careful study with a microscope often shows

the presence of nonmetallic impurities or secondary microconstituents in the boundaries which tend to lower the strength. They can cause fracture to start in these regions and may even embrittle the metals. When grain boundary constituents are present, fracture does not necessarily originate or follow along the grain boundaries; more often it originates within or at interfaces of grain boundary constituents and then propagates by following interfaces or preferred planes of these constituents. If we want to be precise in describing the appearance of such fractures, we should use the term "pseudo-intergranular"; however, in this lecture, I shall continue to refer to them as "intergranular".

Some excellent examples were obtained in a study of cast steels undertaken five or six years ago. A fracture of this type is shown in Fig. 5. The general impression one obtains is that the fracture path followed grain surfaces. In reality, if we should look through the microscope we shall see that it follows across or along interfaces of grain-boundary constituents and, to some extent, through the matrix.

It is not necessary for grain-boundary constituents to be brittle for them to cause intergranular fractures. As an example of this condition, one cast steel showing intergranular fracture had thin networks of ferrite at grain boundaries of an otherwise fully martensitic matrix (Fig. 6). Its path of fracture was through the ferrite networks, making it appear intergranular. A heat treatment which removed the ferrite networks altered the type of fracture and made it transgranular.

Grossmann, who investigated the toughness of hardened steels, had also observed that fractures could occur along ferrite networks. He found that small amounts of ferrite, as little as 2 to 5% of the total microstructure, when located in grain boundaries, led to brittleness. He also found that 30 to 50% of the microstructure must be ferrite before the soft ferritic regions were ductile and the steels became tough in the notched-bar impact test. To explain this behavior, he suggested that the embrittling effect of ferrite resulted from its low fracture strength and its inability to flow under the multi-axial state of stress imposed on it by the surrounding hard, unyielding masses of martensite.

We are all familiar with the more general case where intergranular fracture is associated with thin films or minute precipitates of brittle grain-boundary material. Typical is the fracture of a cast steel having precipitates of aluminum nitride in regions formerly occupied by the boundaries of primary austenite grains.

When the aluminum nitride forms a nearly continuous network, fracture follows the coarse network — even after a heat treatment that removes the as-cast structure and refines the grain. The network is not affected by the heat treatment; fracture continues to occur through it. While the microscope showed the steels to be fine grained after heat treatment, the fractures made them appear to be very coarse grained.

When the amount of aluminum nitride is too small to form continuous networks, the nitride precipitates at the

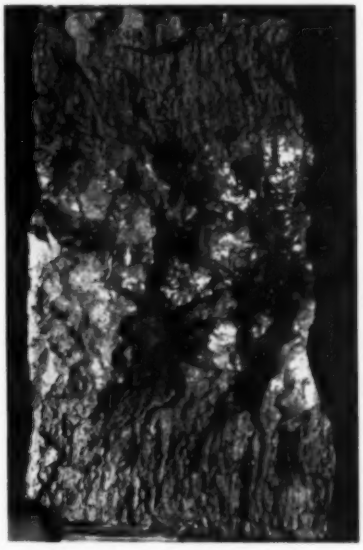
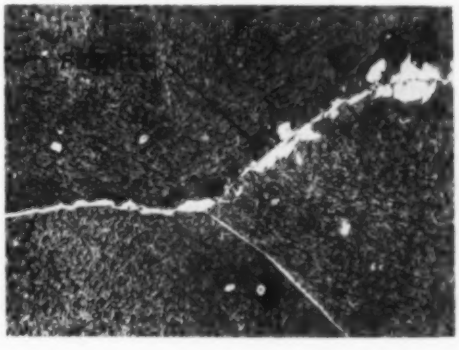


Fig. 5 (Left) — "Pseudo-Intergranular" Fracture in a Cast Steel. Microscopic examination proves that the path of fracture is primarily across or along interfaces of grain-boundary constituents

Fig. 6 — Microstructure of Steel Casting Which Fractured Through the Ferrite Network. A heat treatment that eliminated this ductile constituent converted the type of fracture to truly transgranular



original grain boundaries of the austenite and grows into the matrix as parallel needles along preferred planes (Fig. 7). When specimens with this distribution of aluminum nitride fail, the fractures are made up of a series of very small step-like separations that roughly follow the general contour of the primary austenite grain boundary. A trace of a typical fracture path has been added in the photomicrograph. Macroscopically such a fracture appears intergranular. In reality, it is made up of a series of transgranular fractures that cross the matrix between the aluminum nitride needles. These tiny fractures are then joined by cracks both through and along interfaces of the needles.

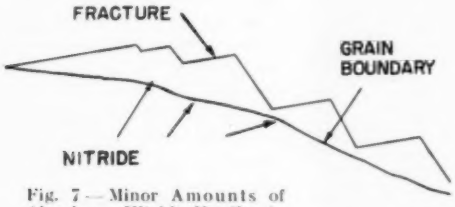


Fig. 7 — Minor Amounts of Aluminum Nitride Needles in Cast Steel Grow as Parallel Needles From Original Austenitic Grain Boundaries, and "Intergranular" Fracture Is Really a Step-Like Series of Transgranular Fractures, as Indicated

I hope by this time I have made the point that we are on uncertain ground when we think of a metal as having only one fracture strength. We must think, rather, in terms of a fracture strength for each constituent in a metal.

Remember that the problem is still more complicated than that, for we must consider also the effects of structure, temperature, composition, strain rate and stress system. Work now in progress at Battelle on molybdenum has given us some helpful data, since it is extremely sensitive to minor changes in these factors and has a behavior pattern apparently characteristic of many metals.

The arc-melted molybdenum* used initially was of commercial quality containing 0.03% carbon, chiefly as carbide particles within the grains and at grain boundaries. The as-cast grains were elongated and oriented with their long axes substantially parallel. Anisotropy was further enhanced by the fact that, on solidifying, a major crystallographic axis in each grain was formed parallel to its long axis. Some of these structural features are shown in Fig. 8, a sketch

*The ingot, obtained from Climax Molybdenum Co., weighed 56 lb. and was 4 in. in diameter and 13 in. long.

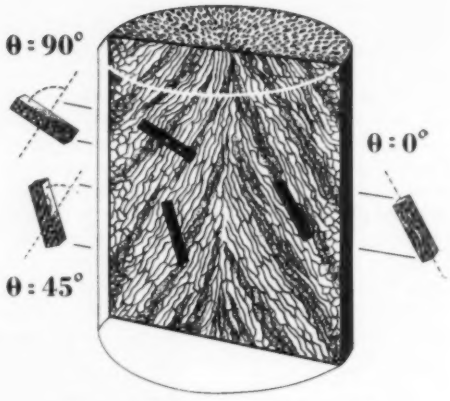


Fig. 8 — Sketch of Crystallographic Conditions in a Section Through an Ingot of Arc-Melted Molybdenum

of a vertical section through an ingot. It was easy to obtain small specimens from such a section in which the angle θ between the major axis of the grains and the direction of the maximum fiber stress in a bend test varied at will from 0 to 90°.

At room temperature and at a constant slow deflection rate in a bend test the molybdenum failed with a type of fracture that was dependent on grain orientation. For values of θ of less than 35°, fracture was by cleavage but was preceded by some plastic deformation. Figure 9 is a photograph of a broken bend-test specimen with grains oriented in this manner. Fracture occurred on planes perpendicular to the major axes of the grains and not on planes where the normal stress was maximum, so grain orientation in such specimens had a greater effect on crack propagation than stress concentration.

When θ was 35° or larger, fracture occurred at considerably lower loads with no visible plastic deformation. The fractures invariably originated in regions near grain boundaries but were propagated both in these regions and along preferred planes in the matrix. Fracture occurred by more than one process — a mixture of the intergranular and transgranular types.

Grain orientation obviously influenced greatly the amount of plastic flow before fracture. Bend specimens of commercial molybdenum of two grain orientations were then used in studying the effect of temperature. In one group of specimens, the grains were oriented longitudinally; in the other, they were oriented transversely to the direction of the principal stress. Except for temperature, the conditions

of the tests were the same as those I mentioned earlier in this lecture.

At testing temperatures below −22° F., the longitudinally oriented specimens fractured abruptly without visible signs of ductility. As the testing temperature increased, however, such specimens withstood an increasing amount of plastic deformation; at 200° F., they bent through 90° without breaking.

Contrast this with grains oriented transversely. The latter were ductile only when above 150° F.; they fractured with no visible plastic flow at lower temperatures. These differences in behavior of specimens of different grain orientations made it apparent that fracture was extremely sensitive both to orientation of the grains and to the test temperature.

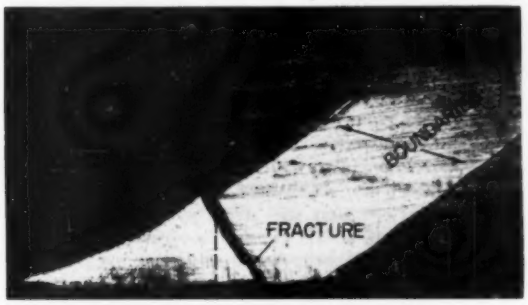


Fig. 9 — Broken Bend Specimen Showing Orientation of Grain, Fracture (Perpendicular to Major Axis of Grain) and Plane (Dotted Line) of Maximum Normal Stress

Next, in studying the effect of *composition*, we were concerned primarily with the impurities, carbon and oxygen. Specimens were obtained from several ingots specially prepared by repeatedly melting in a vacuum-arc furnace to insure high purity. (They contained about 0.002% carbon and about 0.0002% oxygen; no carbides could be detected in the microstructure.) This highly purified metal showed excellent bend ductility at room temperature; even when the grains were oriented transversely some specimens bent through an angle of 90° without breaking. Under similar test conditions, as I mentioned earlier, commercial molybdenum with this grain orientation was extremely brittle.

Sufficient data were obtained in our studies to show the effect of temperature and strain rate on the transition from ductile to brittle behavior. Transition curves for four groups of specimens, representing both commercial and high-purity molybdenum of two grain orientations, are shown in Fig. 10, which was prepared by plotting the logarithm of the deflection rate, or the approximate strain rate, against the reciprocal of absolute temperature. The criterion for ductility was a visible display of a permanent bend angle. The behavior of each group of specimens was characteristically ductile for temperature and strain rate conditions existing below its respective curve; temperature and strain rate conditions that would be plotted above its curve resulted in brittle behavior. As compared with commercial molybdenum, the transition from ductile to brittle behavior of high-purity metal was at considerably lower temperatures. These transitions were clearly related to variables such as grain orientation, temperature, strain rate, and composition.

GENERAL VIEW OF PROBLEM OF FRACTURE

In citing the above examples, I have demonstrated that microstructural features are not only important but are directly responsible for several kinds of processes that can lead to fracture. We can now conceive a general picture of the fracture problem:

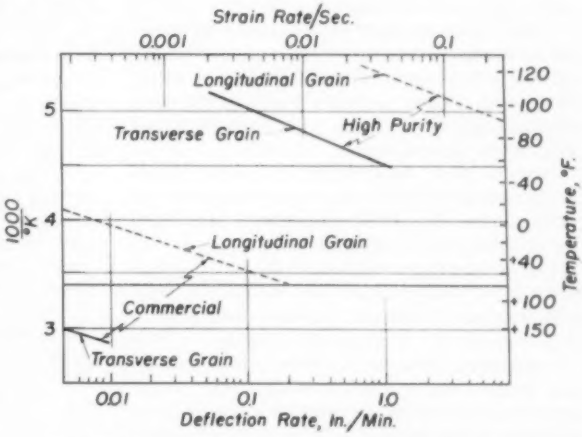


Fig. 10 — Log Strain or Deflection Rate Against Reciprocal of Absolute Temperature for Molybdenum, Varying as to Purity and Grain Orientation. Transition from ductile to brittle behavior depends on all four factors

In sharp focus in the background is the significant fact that all metals are heterogeneous. Rarely do they show isotropic behavior. For that reason, any concept of fracture of metals based on the assumption of isotropy is not adequate. Of course, I do not want to discount the fact that the assumption of isotropy has been close enough to the truth for many situations, especially in engineering design. I want to suggest, however, the need for utilizing the more realistic concept of anisotropy.

Because of anisotropy, the various fracture processes in metals ought to be defined in terms of critical stresses for failure by shear, by cleavage on crystallographic planes, or by separation on grain or phase surfaces. Fracture, then, should not be considered an isolated event; rather it is the end of a number of possible events which take place as the load on a metal increases.

Fracture in some metals depends to an important extent on the condition of boundaries between grains and on the nature of microconstituents at grain surfaces. We do not necessarily conclude that cracks in such microconstituents will cause metals to be brittle. Whether such tiny cracks can propagate by a brittle mechanism will depend largely on the ability of the supporting matrix to deform and reduce the stress concentrations about such cracks. A matrix with sufficient ductility should be able to accept a crack within itself, or in another phase, without that crack serving as the trigger for cataclysmic fracture. But if the ductility of the matrix is low, such a crack can cause cataclysmic fracture.

Since I have titled this lecture "A Metallurgist Looks at Fracture", it seems but fair to tell you what appear to stand out as essential elements in a more complete theory of the fracture behavior of metals, at least from the viewpoint of the metallurgist.

In the first place, inasmuch as the interrelationships between structural features of metal and the origin and propagation of a crack are so complex, we should not expect to find simple physical and mathematical relationships. Instead, we must realize that we are dealing with a highly complex problem containing a large number of simultaneous variables.

Secondly, there is the inescapable conclusion that, even though ordinary mechanical properties do not always disclose the fact, metals have more than one fracture strength. Consequently, fracture mechanisms cannot be defined in terms of a single fracture strength. If one merely asserts that fracture comes about as soon as the normal stress exceeds the fracture strength, such a statement is an oversimplification and fails to take into account the importance of microstructural anisotropy, among other things.

By accepting the proposition that a metal has more than one fracture strength, it should be possible for us to extend the concept of flow and fracture strengths, introduced more than 40 years ago by Ludwik, by including relations among *all* flow and fracture strengths that are common to a metal. This would help predict, or at least account for, the behavior of the metal under various stress systems. Such an extension of Ludwik's concept would take into account the individual values for the fracture strengths at grain surfaces, at phase interfaces, and at crystallographic planes. Further, it would recognize the need for evaluating the effects of temperature, strain rate, composition, and stress system on *each* of the fracture strengths that contribute to the fracture behavior of a metal. It would even go so far as to suggest that there is a particular flow strength for each constituent in a metal and that through a mechanism of interactions, flow in one constituent may affect flow in other constituents to the extent that the stress system is changed. The value of the concept of multiple flow and fracture strengths would seem to come from the possibilities it offers in relating fracture of metals to the crystallographic, mechanical, and microstructural features.

ACCOUNT FOR VISIBLE PHENOMENA

We can sum up the situation on fracture by paraphrasing a statement made by Professor Campbell 37 years ago on the status of our theory on the constitution of steel. By the simple act of substituting "fracture" or "metals" for the word "steel" his remarks then become:

> "To anyone who has paid much attention to the historical development of research on 'fracture' it must be evident that any theory of 'fracture' sufficiently comprehensive to include all the known facts concerning the 'fracture' behavior of 'metals' and to serve as a basis for future experimental work, must be a composite conception representing the accumulated experiences and ideas of a large number of research workers . . . . .
>
> "It is, therefore, to be hoped that before long a theory of 'fracture' broad enough to include a reasonable explanation of all the known facts concerning the 'fracture' behavior of 'metals' and not contrary to any known facts may be worked out."

A Sampling From World Metallurgical Congress Visitations

Foreign conferees to the First World Metallurgical Congress gathered in New York City during the week of Sept. 10, and on Monday, Sept. 17, they started various study tours lasting four weeks and concluded with a fifth week in Detroit at the American Society for Metals' National Metal Congress and Exposition. Eight study tours were arranged, each providing the traveller a broad view of a certain branch of American metal industry. While they were somewhat exacting in their demands on physical endurance, the information and inspiration gained was good payment — as is proved by the following brief accounts of individual plant visitations written by John Parina, Jr., associate editor, and Harold J. Roast, consulting editor.

Inspection and Control in Process

Study Group 6 ("Testing and Inspection") at Aliquippa Works of Jones & Laughlin

MASS-PRODUCTION is perhaps a more distinctive expression for the technological philosophy of the United States than any other combination of words. It was not surprising, therefore, that when W.M.C. Study Group No. 6 visited Jones & Laughlin's Aliquippa Works near Pittsburgh they showed as much interest in production equipment and processes as in inspection and testing, the group's field of special interest.

Features that seemed to make the strongest impression on the visitors were the plant's large finishing capacity, the high speeds of the blooming mill, the five-stand tandem cold finish mill, the continuous cleaning line that serves it, and the fact that there was nowhere any clutter, any pile of half-finished material awaiting further treatment — despite the enormous amount of steel that was going through the plant. Large finishing capacity is a distinctive feature of the mill. It has been carefully planned to provide ample capacity for handling either an entirely basic or bessemer output should one or the other of these production lines become unable to handle its share. If there is a bad breakdown in any finishing mill, the preliminary operations are quickly shifted over to serve another mill, either idle or running below capacity. Important as these physical features are, in the final analysis they are only the result of a number of very closely related influences responsible for this country's world leadership in steel production. How this tremendous capacity came into being, which was the question of some conferees, is difficult to express in a few sentences.

During the horse-and-buggy days, American business jogged along at an equally complacent pace. True, a kind of mass production did come into being during the Revolutionary Period when Wilkinson began manufacture of cold-cut nails with his machine. In 1854, a year after the business of Jones & Laughlins, Ltd., was established, Samuel Colt provided the second essential step toward successful production methods with his idea of interchangeable gun parts. Progressive operations in dies or machine-tool fixtures were common in the watch and clock industry prior to 1900. But, it remained for the automobile assembly line to demand vast and constant improvements in machine tools, presses and hammers. These repetitive operations, in turn, demanded metal of uniform quality, especially steel that could be depended on from heat to heat. Specifications became more demanding. Intermeshed and interwoven with this new industrial movement were the equally young techniques of mass selling, advertising campaigns, and all the trappings. These, briefly, are some of the factors that have contributed to the steel industry's growth, represented by Aliquippa — built in the 1906-1910 years, but constantly perfected, frequently enlarged.

Aliquippa Works typifies the big steel plants of the United States in many ways — it is big in size and capacity (having an annual capacity of 1,800,000 tons of pig iron and over 1,700,000 tons of steel) and has achieved a high degree of efficiency through integration. Just as important as its degree of integration is the

close relationship between quality control and high productivity, and this dependence of production on metallurgical control is in evidence in every phase of its manufacturing operations.

The three main functions of the metallurgical department are quality control, reductions of rejections and improvement of yields, and the development of new products and processes. The metallurgical department has a staff of 140, excluding the plant chemical force, and is directed by L. Van Ormer, chief metallurgist, and A. T. Albright, assistant chief metallurgist. Their organization is divided into four sections, each of which is directed by a supervising metallurgist. These sections are *(a)* steel works, blooming, 10 and 14-in. mills, and the statistical division; *(b)* welded and seamless tube mills; *(c)* tin-plate department; *(d)* wire mill and control laboratory. In addition to the metallographic and main physical laboratory, other laboratories and control stations are located throughout the plant. The plant metallurgical department is directly responsible to not only the works' general superintendent but to a company vice-president who is also director of technology. Quality control of raw materials — iron ore, limestone and coal — is under the jurisdiction of the general technical department which maintains chemical laboratories at the source. Check analyses, however, are run on the material at the works before they enter the blast furnaces.

All orders received by the works are referred to the metallurgical department for assignment as to specification, grade and processing. Factors such as chemical composition, steelmaking practice, ingot mold practice, discard, conditioning practice, mechanical properties, testing and finishing are written in the specifications. Metallurgical observers and testers, working in the various departments of the plant, see to it that these specifications are followed. Chemical and physical tests required during the course of steelmaking and processing are made by the departmental laboratories located in the plant.

Statistical quality control, or the system of reducing rejections and improving yields through the correlated control of the variations in processing that affect quality and yield, is "old stuff" to the metallurgical investigators at Aliquippa. With due respect to the new generation of efficiency analysts, Aliquippa's statistical measures are smooth working and rewarding without the dubious advantage of involved mathematics. The metallurgical department maintains its own electric tabulating equipment operating on a punched card system. The more than three million punched cards on file can be readily sorted for statistical studies.

Some of the quality control methods developed at the plant include the use of a photoelectric cell ("electric eye" to turn off the bessemer blow when the carbon content has been lowered to a predetermined point; a "carb-analizer" to determine carbon content of the steel at the openhearth by means of the sample's magnetic permeability; and the blowing tube type of immersion bath pyrometer, utilizing a radiation thermopile (developed in cooperation with Leeds & Northrup Co.). Also developed here is an oil film for coating electrolytic tinplate that is so thin that one drop of oil will cover a surface area equal to a 42-in. strip 30 ft. long. The oil provides lubrication in can manufacture and prevents rust in storage. J. P.

Tour Group and Guides at Aliquippa

Manufacture of Special Bronzes

Study Group 2 ("Nonferrous Refining, Rolling and Fabrication") at Ampco Metal, Inc., Milwaukee

A NONFERROUS FOUNDRY casting some six million pounds a month, employing about 800 people in foundry proper, associated heat treatment department and machine shop, is worthy of inspection in any country. Add to this the fact that practically all of the production can be characterized as "special" alloy for especially severe service, produced under meticulous control, and you have a combination that is perhaps unique in the world. At least that seemed to be the consensus of the foreign conferees after visiting Ampco Metal, Inc., in Milwaukee.

Long experience with special aluminum bronzes has convinced the staff that double melting is necessary for the precise analyses required. The first melt gives a master alloy from the virgin metal employed; this forms the basis for the final alloy. To this is added whatever is called for in melting to the final composition. "Ampco" metals are aluminum bronzes containing about a third as much iron as aluminum, plus fractional percentages of metals insoluble in the matrix to "seed" a fine crystallization. A routine hardness test on a small block cast from each melt helps control machinability and mechanical properties of the eventual castings.

Melting is conducted for the most part in indirect arc rocking furnaces; some natural gas fired furnaces are also used. The large electrics have a capacity of 5500 lb. We saw an ingot 25 in. square weighing 11,000 lb. that was to be used for forging. Strainer cores are generally preferred to other means of holding back the dross that is characteristic of aluminum bronze.

In the conventional sand molding foundry a great variety of castings were being produced, among them being steel mill "slippers" up to 1500 lb. each, with a tolerance plus or minus of $\frac{1}{32}$ in. with no machining. Many forming dies, large and small, were in various stages of manufacture; apparently this special bronze has many features which recommend it to the makers of pressings and stampings of stainless steel.

Much centrifugal casting is being done. Some of the smaller machines — all home-made — are arranged so the axis can be changed, during spinning, to any desired angle from the vertical. When 25 castings, more or less, are required of a single simple shape, the molds are machined from carbon electrodes, 25 in. diameter being the largest size available. Where the number of castings is much over 25 or for larger castings, steel or Meehanite cast iron molds are lined with a suitable sand mixture. Centrifugal castings having complicated cores and large bushings flanged at both ends are made in sand-lined molds. Other centrifugal castings are cast vertically, 40 in. in height with a 3-in. wall, weighing 10,000 lb. each.

For good sized, centrifugally cast Ampco castings, $\frac{1}{4}$ in. of metal is usually machined from the outside and $\frac{1}{2}$ in. from the inside.

Another quite unusual possession of a nonferrous foundry is a department containing large extrusion presses. While we were there a 7½-in. billet was being extruded into an aluminum bronze wire $\frac{3}{16}$ in. in diameter. The billet was at a bright red heat when put in the machine. We were told that the press is adaptable for the making of condenser tubes. Also that the Ampco Co. was the only firm extruding beryllium bronze with beryllium content between 1.7 and 3%. The tensile strength of this alloy so extruded is 100,000 psi.

H. J. R.

Welding of Auto Bodies and Soldering of Radiators

ALTHOUGH the automotive industry is not necessarily the only or the foremost exponent of economical manufacturing methods, it still is in the vanguard in this respect. Therefore, a trip through a plant such as that of the Murray Corp. of America, Detroit, which was taken in company with World Metallurgical Congress Study Group No. 5 ("Welding and Joining") is a nice bit of education in cost-cutting techniques.

Selection of fabricating methods for automobile parts is based to a great extent on cost considerations, being influenced often by no more than a mill or two saved on each part in labor or material; this minute amount rapidly pyramids into large sums in a year's time. Another very important consideration is that the welded joints, especially on the exposed portions of the body where a few are used, require a minimum of expensive finishing to obtain a smooth surface.

At Murray's plant, the formed frame and body components are joined entirely by welding.

However, the daily production of 4000 frames is now split rather evenly between welded and riveted fabrication, the latter to be supplanted by welding within the near future. Although practically every type of welding technique is used to some extent in joining either the frame or body parts or one to the other, resistance welding is by an overwhelming margin the widest used. This, incidentally, is so not only at Murray but throughout the automotive body industry. Factors influencing the selection of this method are its relatively high output per man and minimum need for manual skill.

Spot welding is the most widely used of the resistance welding processes. The body plant uses 600 portable guns (all of which are equipped with air-actuated cylinders to produce the necessary pressures) for the subassemblies and final assemblies. Stationary spot welding machines, of which there are about 300, are used for small assemblies which can be handled easily and require only a few welds. Large subassemblies that require a number of welds, such as floor panels, doors and trunk lids, are jigged and handled by automatic multiple welding machines which make up to 250 welds at a time. Arc welding is limited to those applications that need reinforcing members — as, for example, struts in the body panels. A low-penetration, high-deposit electrode is used for these welds. Oxy-acetylene welding finds its widest use in providing reinforced joints — as between body panels and the side support bars. Such welds are made with a low-carbon filler rod.

The only place where seam welds appear on the outside surface of the body now being made at Murray Corp. is on the tail quarter panel. These pieces are joined by "Heliarc" welding, of which there are ten stations. It makes a joint which does not require soldering to fill up depressions or considerable grinding to obtain a smooth surface. Butt welding is used also — this for joining the corners of the frames of the quarter windows.

The main members of the all-weld fabricated frames are made of two channels which are joined by the submerged arc process on two machines. Both of these machines, each of which is equipped with six heads with individual controls, have welding speeds of 140 in. per min. This equipment represents an investment of a million dollars, yet if they pare off another fraction of a cent from the cost of frame assembly, they will soon pay for themselves.

This is just another step the company has taken to reduce the average cost of 8 mills for each weldment to an even lower level. J. P.

TOUR GROUP 2's trip to McCord Corp.'s Detroit plant for manufacturing radiators for automobiles and trucks gave this Canadian visitor, at least, a greater respect for the car's cooling system. As we progressed through the plant, it became evident that the making of a radiator was anything but a simple process — in fact, it must be seen to be understood.

The principle evidently is to provide thin rectangular brass tubes surrounded by thin copper sheet formed in a complicated design, the object being to cool the hot water entering these tubes by transferring the heat to the surrounding copper so that the fan could, in its turn, readily dissipate the heat by a blast of air.

Joining of the tubes themselves, and assembling of the tubes and formed copper sheet, together with the necessary inlets and outlets, is all done by soldering. For this the plant uses 750,000 lb. of solder a year of three compositions — either 30% tin, 70% lead, or 38% tin, 62% lead, or 25% tin, 75% lead (the last mentioned only in small amount).

The copper sheet used is quarter hard, 0.004 in. thick. The brass is 70% copper, 30% zinc. The forming machine is fed with the narrow strip brass at the rate of 155 ft. per min. As there are four machines working, this gives a daily production for one eight-hour shift of 300,000 ft., or 60 miles of tubing, a day!

Speed was the most outstanding feature of the whole production line. We saw copper sheet being deformed in a most complicated manner at the rate of 100 ft. per min., the final product being the strips used for separating the tubes.

To join the tube and copper separators to the outer frame, the whole is first submerged in a suitable flux solution and then put in an oven, whereupon the solder (already on the various parts) melts, making the necessary joint. The radiator is then removed and all excess solder immediately blown out, while still molten, by compressed air.

The assembly then passes on, various connections are attached, and it finally reaches the testing platform where all the openings but one are cleverly sealed, and the unit tested with compressed air at about 20 psi. Leakproof radiators are then submitted to a vibration test much harder than that met in ordinary use. If it still remains tight it is considered satisfactory for shipment.

A wind tunnel is also maintained to check the cooling efficiency of the sample radiators removed for test and to study the effect of new designs or modifications. H. J. R.

(More Tour Notes on Page 81)

NICKEL ALLOY IRONS
develop improved properties
plus all the basic advantages of plain cast iron

PLAIN GRAY IRON is, structurally, a steel matrix containing graphite flakes. Engineering, physical, processing and service properties are wholly dependent upon the character and disposition of these flakes, and upon the nature of the matrix.

The matrix of nickel alloyed irons closely resembles the pearlitic matrix found in high carbon steels, whereas the matrix of ordinary plain iron resembles that found in low carbon steels. Compositions of nickel alloy irons can be adjusted to reduce "chill" in thin sections without risk of forming "spongy" regions in heavy sections. This promotes uniform strength, improved machinability, pressure tightness and wear resistance.

Hardness in nickel cast irons results from improvement of the matrix. Chilled areas and hard carbides, which impair machinability, are obviated. Nickel improves response to heat treating. In fact, use of nickel alone or with other alloying elements plays an important part in meeting a variety of requirements.

Accordingly . . . nickel alloyed irons permit production of castings with high levels of the following properties:

Strength

Tensile and transverse strengths of castings are greatly increased by the addition of nickel to cast irons of properly adjusted base mixture. The ratio of compressive strength to tensile strength is retained. Greater uniformity of strength in thick and thin sections is achieved.

Elasticity

The elastic modulus increases with strength. In this respect nickel-containing irons of the high strength type possess good stiffness and do not deform permanently under loads that would be damaging to irons of lower elastic modulus.

Damping Capacity

The damping capacity inherent in gray cast iron is not impaired by the presence of nickel.

Wear Resistance

The uniformly pearlitic matrix of nickel cast irons appreciably improves wear resistance. The uniformly fine graphite flake distribution, achieved in suitably processed irons *without formation of a poor wearing dendritic condition*, affords optimum resistance to wear and galling.

Pressure Tightness

Characterized by dense grain structure and fine dispersion of graphite throughout, nickel alloy irons are close-grained and offer an extraordinary degree of pressure tightness under high hydrostatic pressures, without sacrificing machinability.

Applications

Heavy machinery frames and *beds* are typical of cast parts that benefit from the rigidity and good damping capacity of nickel cast irons. *Cylinder* and *pump liners, gears, dies, machine tool ways, saddles* and *tables* exemplify parts produced in nickel irons to assure greatly increased strength and wear resistance. And nickel alloyed iron is used for *heavy duty brake drums* to resist heat checking, thermal shock, wear and galling. The nickel cast irons are readily heat treated, and respond particularly well to flame and induction hardening.

At the present time, the bulk of the nickel produced is being diverted to defense. Through application to the appropriate authorities, nickel is obtainable for the production of engineering nickel cast irons for many end uses in defense and defense supporting industries.

The International Nickel Company, Inc.
Dept. MP, 67 Wall St., New York 5, N. Y.

Please send me booklet entitled, "Guide to the Selection of Engineering Cast Irons."

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EMBLEM OF INCO SERVICE

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Approximate Strength of Important Jet Engine Alloys (Round Test Bars)

Based on compilation for Oak Ridge National Laboratory by G. H. Boss. Since optimum properties depend upon fabrication methods and heat treatment, the references should be consulted for such data.

Temp.	Tensile Test		Stress-Rupture			Creep Data	Ref.*
	Strength	Elong.	10 Hr.	100 Hr.	1000 Hr.		
S-816 (N.D.R.C. 76)							
			42 Co, 20 Cr, 20 Ni, 4 W, 4 Cb, 4 Mo, 3 Fe, 1.3 Mn, 0.6 Si, 0.40 C				
1200	112,000	22.0	75,000	62,000	48,000	29,000 /(a); 42,000 /(b)	1, 2, 3
1350	98,000	23.0	49,000	37,000	28,000	19,000 /(a); 26,000 /(b)	12, 18
1500	73,000	23.0	30,000	24,000	18,000	12,000 /(a); 16,000 /(b)	19
1600	51,000	17.0	20,000	14,500	10,500	5,000 /(a); 9,800 /(b)	
1700	44,500	15.0		10,000	5,800		
1800	25,500	20.0	8,800	5,300	3,000		
Cast Haynes Stellite No. 21 (N.D.R.C. 10, or Modified Vitallium)							
			60 Co, 27.5 Cr, 5.5 Mo, 2.5 Ni, <2.0 Fe, 1.0 Mn, 0.6 Si, <0.35 C				
1200	85,400	2.3	70,000	52,000	42,000		
1350	79,300	3.8		36,000	27,500	10,000 /(c); 0.0,13 /(d); 0.0,1 /(e); 0.0,8 /(f) 15,000 /(c); 0.0,3 /(d); 0.0,19 /(e); 0.0,1 /(f)	2, 4 18, 19
1500	59,000	6.8		22,000	14,200	7,000 /(c); 0.0,22 /(d); 0.0,1 /(e); 0.0,65 /(f)	
1600	41,500	19.3		16,700	13,200	7,000 /(c); 0.0,125 /(d); 0.0,44 /(e); 0.0,44 /(f) 10,000 /(c); 0.0,33 /(d); 0.0,13 /(e); 0.0,13 /(f)	
1800	33,000	35.0	12,500	9,000	6,800		
K-42-B (N.D.R.C. 77)							
			42 Ni, 22 Co, 18 Cr, 13 Fe, 2.6 Ti, 0.7 Mn, 0.7 Si, 0.2 to 0.6 Al, 0.05 C				
1200	117,000	9.0	76,000	65,000	38,000	35,000 /(g)	
1350	97,000	4.0	50,000	37,000	26,000	24,000 /(a); 33,000 /(b); 25,000 /(g)	2, 3, 5
1500	54,000	10.0	22,000	16,000	10,000	7,500 /(a); 13,500 /(b)	10, 11
1600	29,000	45.0					
Timken 16-25-6 (N.D.R.C. 15 and N.D.R.C. 49)							
			50 Fe, 25 Ni, 16 Cr, 6 Mo, 1.5 Mn, 0.9 Si, 0.18 N, 0.09 C				
1200	100,000	13.0		42,000	32,000	9,000 /(g); 22,000 /(a)	2, 3
1300						8,400 /(g); 14,000 /(a)	13
1350	60,000	40.0	42,000	28,000	19,000		
1400					12,500	4,000 /(g); 8,200 /(a)	
1500	48,000	27.0	18,500	12,900	9,000	2,000 /(g); 4,600 /(a)	
1800	21,000	22.0					
Discaloy (N.D.R.C. 78)							
			55 Fe, 25 Ni, 13 Cr, 3 Mo, 2.0 Ti, 0.7 Mn, 0.7 Si, 0.5 Al, 0.5 C				
1200	104,000	19.0	70,000	52,000	38,200	1,000 /(i); 35,200 /(j); 38,000 /(k) 100 /(i); 39,200 /(j); 42,500 /(k)	2, 3 10, 14
1350	81,000	14.0	44,000	30,000	17,000		18
19-9 DL (N.D.R.C. 46)							
			66 Fe, 19 Cr, 9 Ni, 1.3 Mo, 1.3 W, 1.0 Mn, 0.6 Si, 0.4 Ti, 0.4 Cb, 0.3 C				
1200	75,000	33.5	39,000	40,000	34,000	25,000 /(a); 11,000 /(h)	
1300	58,750	22.5					2, 3, 5
1350			35,000	23,000	15,500	13,000 /(a)	6, 14
1500	32,500	53.0	18,000	13,300	10,000	7,100 /(a)	18

Temp.	Tensile Test		Stress-Rupture			Creep Data	Ref.*
	Strength	Elong.	10 Hr.	100 Hr.	1000 Hr.		
N-155 (Multimet, or N.D.R.C. 21, or N.D.R.C. 66 with <0.16% C)							
			27 Fe, 21 Cr, 21 Co, 21 Ni, 3.2 Mo, 2.5 W, 1.5 Mn, 1.2 Cb, 0.7 Si, 0.33 C, 0.14 N				
1000	94,000			78,000			2, 3
1200	80,000		70,000	53,000	42,000		4, 5, 6
1350	60,000	14.0	40,000	31,000	24,500	12,000 /(c); 0.0,42 /(d); 0.0,25 /(e); 0.0,13 /(f) 15,000 /(c); 0.0,12 /(d); 0.0,79 /(e); 0.0,38 /(f)	11 18, 19
1500	45,000	24.5	23,000	18,000	13,000	7,000 /(c); 0.0,8 /(d); 0.0,42 /(e) 10,000 /(c); 0.0,9 /(d); 0.0,9 /(e); 0.0,17 /(f)	
1800				6,400	4,200		
Haynes 25 (L-605)							
			50 Co, 20 Cr, 15 W, 10 Ni, <2 Fe, 1.5 Mn, 0.5 Si, 0.10 C				
1500	50,000	15.0	30,000	22,500	17,000	9,000 /(c); 0.0,48 /(d); 0.0,37 /(e); 0.0,7 /(q) 12,000 /(c); 0.0,1 /(d); 0.0,8 /(e); 0.0,65 /(q)	
1600			23,000	16,500	12,000	8,000 /(c); 0.0,8 /(d) 0.0,33 /(e); 0.0,29 /(f)	
1700	30,000		17,500	11,000	7,200	6,000 /(c); 0.0,43 /(d); 0.0,33 /(e)	
1800	21,000	16.0	11,500	7,200	4,500	4,000 /(c); 0.0,88 /(d); 0.0,76 /(e)	11, 18
Inconel X (N.D.R.C. 99)							
			>70 Ni, 15 Cr, 7 Fe, 2.5 Ti, 1.0 Cb, 0.7 Al, 0.65 Mn, <0.50 Si, 0.2 Cu, 0.08 C				
1200	120,000	9.0	92,000	78,000	66,000	1,000 /(i); 42,000 /(l); 62,000 /(m)	2, 6
1350	92,000	7.0	60,000	48,000	40,000	1,000 /(i); 32,000 /(l); 36,000 /(m)	7, 8
1500	52,000	22.0	38,000	26,000	18,000	1,000 /(i); 14,000 /(l); 16,000 /(m)	18
1600	34,000	47.0	18,000	11,000	7,000	1,000 /(i); 4,000 /(l); 6,000 /(m)	
Nimonic 80 (N.D.R.C. 29)							
			75 Ni, 21 Cr, 2.5 Ti, 0.8 Al, 0.6 Mn, 0.5 Si, 0.04 C				
1110	97,000	25.0		75,000			2, 3, 5
1200			78,000	61,500	45,000	1,000 /(i); 39,000 /(l); 45,500 /(m)	6, 9
1300	76,000	7.0		46,000		1,000 /(i); 27,000 /(l); 30,500 /(m)	18
1350			56,500	39,000	23,300	1,000 /(i); 19,000 /(l);	
1380						1,000 /(i); 15,000 /(l); 21,000 /(m)	
1500	63,200	8.0		21,000	12,000		
1800				4,900			
Hastelloy B (N.D.R.C. 94)							
			65 Ni, 28 Mo, 5 Fe, <1 Mn, <1 Si, 0.4 V, <0.12 C				
1200				54,000	33,200	7,400 /(a); 20,000 /(b)	1, 2, 3
1300	85,000	9.0		37,000			4, 5
1350			48,000		25,000		12
1500	77,000	27.0	25,000	16,800	11,300	2,800 /(a); 4,800 /(b)	
1600	32,500	45.0	16,700		8,300		
1800	31,500	70.0					
2000	13,100						
Type 347 Stainless Steel							
			67 Fe, 18 Cr, 10.5 Ni, <2.0 Mn, <1.0 Si, 1.0 Cb, <0.08 C				
1000	61,500			32,000 /(o)	19,000 /(p)		1, 2
1100	57,000	39.0	30,000 /(n)	25,000 /(o)	14,000 /(p)		15, 16
1200	50,000		21,000 /(n)	17,000 /(o)	8,500 /(p)		17, 18
1300	40,000	51.0	9,000 /(n)	11,000 /(o)	5,000 /(p)		
1400	31,000			7,000 /(o)	2,500 /(p)		
1500	23,000	76.0		4,500 /(o)	1,100 /(p)		
1600				3,500 /(o)			

Footnotes

* References listed on p. 146.

(a) Stress for minimum creep rate of 0.0001% per hr.

(b) Stress for minimum creep rate of 0.001% per hr.

(c) Stress for remaining data on this line in hours.

(d) Creep rate per hr. at 500 hr.

(e) Creep rate per hr. at 1000 hr.

(f) Creep rate per hr. at 2000 hr.

(g) Stress for 0.1% elongation in 1000 hr.

(h) Stress for 0.00,001% creep rate per hr.

(i) Time of test for remaining data on this line

(j) Stress for total elongation of 0.5%

(k) Stress for total elongation of 1.0%

(l) Stress for 0.2% total strain (elastic plus plastic elongation)

(m) Stress for 0.2% permanent (plastic) strain

(n) Stress-rupture for 100,000 hr., grain size 4 to 6

(o) For annealed bars

(p) Stress for 1.0% creep in 10,000 hr., annealed bars

(q) Creep rate per hr. at 3000 hr.

Mechano Set - King Size....

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	Achromatic		Fluorite		Apochromatic		Huyg.	Hyper.	Amp.	
	Mag.	N.A.	Mag.	N.A.	Mag.	N.A.				
25×	6.5×	0.10					5.0×			7.7
50×	6.5×	0.10					5.0×			15.4
75×	6.5×	0.10					6.4×			18.0
	8.0×	0.20					6.4×			14.6
	13.0×	0.25					5.0×			11.5
100×	8.0×	0.20					6.4×			19.5
	13.0×	0.25					5.0×			15.4
150×	13.0×	0.25					6.4×			18.0
200×	20.0×	0.40						10×		10.0
250×	20.0×	0.40						10×		12.5
500×	37.0×	0.65							10×	10.8
750×			55×	0.85	60×	0.95			10×	11.0
1000×			53×	1.00	60×	0.95			10×	9.8
1500×			85×	1.25	77×	1.40			10×	16.2
2000×					77×	1.40			10×	14.0
									10×	15.0
									10×	16.8
									10×	23.3

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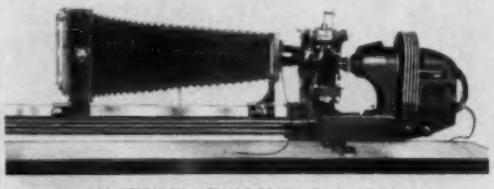

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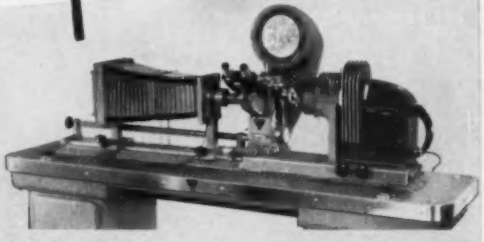

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Study Group 6 ("Testing and Inspection")
at Leeds & Northrup Co., Philadelphia

ACCOMPLISHMENTS and growth at Leeds & Northrup Co. of Philadelphia since its organization in 1906 seem to parallel the advance of the metallurgical art and science in the first half of the present century. At its beginning, individual temperatures could be measured, but with extreme difficulty; temperature control was the function of the skilled furnaceman. Real progress, not only in the shop but in the laboratory, began with the invention of durable thermocouple elements, cheaper than platinum, and accurate hardness testers. With these foundation stones, metallurgists were able to put to good use the continual stream of improvements in temperature measuring devices, temperature controllers, and furnace atmosphere controllers that have since been made.

Inspection of an extensive factory making instruments and furnaces, such as the one at Philadelphia, cannot help but excite some interest in how such apparent perfection has been reached. Leeds & Northrup's pyrometric equipment is based on a potentiometer — whereby the electromotive force generated at the hot junction of the thermocouple is measured. Their first equipment was designed for electrical experimentation and research in industrial and college laboratories. However, General Electric Co. and then Packard Motor Car Co. tried these in their metallurgical departments and obtained very satisfactory results. They proved to have the advantage of greater accuracy and better response than the simpler devices that measured the tiny current generated by the thermocouple. A clever and automatic device for "balancing" the potentiometer circuit then prepared the way for a long line of improvements and a wide range of applications in measurement, recording and control — reaching as far as equipment for measuring the radiation from white-hot roofs and walls of steelmaking furnaces to measuring and recording densities of spectral lines in spectrographic chemical analysis.

A technological advance in one field often necessitates an equally significant advance in another field, so that the fullest advantage can be realized of the prior development. It was inevitable that furnaces of improved design would be needed by the industry using these improved instruments. Our foreign visitors were fairly well acquainted with these developments, and of the contributions of the firm that was acting as host on this particular day. Americans, of course, know well the pot-type tempering furnace, electrically heated, with fan in base for circulating the atmosphere; the "hump" hardening furnace with devices that measure the temperature of the charge constantly and plot a time-temperature curve showing when the charge passes through the transformation range, and the adaptation of the latter for carburizing by a "Homocarb" fluid", injected into the furnace and gasified.

The last child of these progenitors is "Microcarb", a means of controlling the active carbon in the furnace atmosphere throughout the entire heating cycle.

Instrument Maker Assembling Wenner Potentiometer of Highest Precision (Leeds & Northrup Co.)

The sensing element for this atmospheric control is an alloy steel wire which rapidly absorbs carbon from the furnace atmosphere, or loses it to the atmosphere, until the two are in equilibrium. With every change in the wire's carbon content, there is a corresponding change in its electrical resistance. The two Microcarb instruments — controller and carbon recorder — translate this resistance directly into terms of per cent carbon, control the atmosphere on that basis, and record the result. Obviously the furnace can be set to maintain existing carbon exactly at the surface of the parts being heat treated, to recarburize a soft skin, to case harden or to decarburize. The sensing element is provided with retractable mounting on the furnace lid and projects into the furnace where it responds to carbon content of the atmosphere exactly as the work itself does. It is connected electrically to a controller which actuates the fluid pump supplying the hydrocarbon fluid.

Another newsworthy development discussed during this inspection and conference is the utilization of steam as a heat treating atmosphere for iron and steel parts — an adaptation of the age-old process of the copper and brass mills, although used for producing an oxidized surface on steel rather than an oxide-free surface on copper alloys.

Steam is fed through an inlet in the bottom of the forced-convection Homo furnace and driven by the fan past the heating elements and through the work chamber. When tempering steel or iron parts, the furnace is first brought up to 700° F. with air atmosphere, then held at this temperature for 30 min. while steam at slightly more than atmospheric pressure is fed into the work chamber, purging out all air. The load is then heated to the soaking temperature and held for the specified time, with steam flowing through the furnace. Work is either air cooled or oil quenched.

The surface on iron or steel parts so treated is covered with a film of magnetite (Fe_3O_4) about 0.0002 in. thick, hard and closely adherent, but said to be of such structure as to absorb and closely hold a lubricant or a rust preventive. Either because of the hardness of this oxide coating or its ability to hold lubricant, steam treated surfaces are notably wear resistant. Cutting tools so treated (twist drills particularly) give higher production per grind because chips do not appear to wear or weld against the flutes.

An interesting application was reported from the powder metal industry. It seems that properly sintered iron compacts, especially when they contain a moderately high degree of porosity, can profitably be given a post-treatment in steam. The internal cavities are then partially filled with Fe_3O_4; indentation hardness of the compact (resistance to deformation) is materially increased. J. P.

Wrought and Cast Magnesium

Study Group 2 ("Nonferrous Refining, Rolling and Fabrication") at Dow Chemical Co. Plants in Midland and Bay City, Mich.

THE MIDLAND PLANT covers 1500 acres and employs 9000 people. There are 600 buildings; six buses running every 10 min. provide transportation about the site. Magnesium represents only 7% of the company's sales dollar, industrial chemicals 50%, plastics 25%, and miscellaneous items the remaining 18%. The price of commercially pure magnesium in ingot form today is about 24½¢ per lb.

Midland is a "Dow town", the population of which is 15,000, including — it is said — some 40 millionaires. The Dow Chemical Co. is somewhat unusual in that it maintains its head offices at Midland, including the top-level executives, rather than in New York City. Evidently these executives feel a liking for and a responsibility to the town which has been created by their operations.

In a preliminary meeting in the company's auditorium we were shown production data that exhibited the enormous impetus to magnesium production from the Korean crisis and the subsequent defense program. Whereas the first magnesium was obtained as a byproduct of the Michigan brines on which the chemical industry is based, and much metal was gained from that source during World War II, present production by Dow is exclusively from the plant at Freeport, Texas, where 150,000,000 lb. of magnesium is produced annually from sea water. The commercially pure pig is shipped to some 52 foundries and rolling mills where it is alloyed and cast into useful shapes or into slabs or billets for rolling mills or extrusion presses. Interest centered around a pile of magnesium slabs, each some 12½ ft. long by 3½ ft. wide and 1 ft. thick. These weighed 3000 lb. each and were to be sent to a new mill where

continuous rolling would give a steady production of the required sheet.

As we went through the plant a truck marked "Fire Prevention" was noticed. An inquiry elicited the fact that the containers were filled with fine graphite powder and some sulphur. This takes the place of water when a magnesium fire is to be extinguished. At another place molten magnesium was being pumped from large alloying pots into small ingot molds, the operation being protected by sulphur which was burned in a trough, the flame being drawn over the surface of the ingots as poured. In fact, sulphur seems to be a most useful material in the pyrometallurgy of magnesium — we found during the afternoon's visit to the foundry that all castings are heat treated in an SO_2 atmosphere.

Of great interest is the continuous melting and production of magnesium rod, if you can apply such a term to a 16-in. round. The metal was, as usual, pumped over to another holding pot, the level of which was kept constant. The mold through which the metal passed was water cooled at a rate to solidify the metal as it passed through; solid magnesium passed steadily to the floor below at 2½ in. per min. When the solid metal reached a predetermined length it crossed the beam of an electric eye. This set in motion the horizontal circular saw which cut across the 16-in. bar, traveling downward, following the metal until the cut was completed. Cylindrical blocks, some 4 ft. long, dropped onto the chute with a resounding bang.

While fracture is one of the means used to enable the operators to control quality, chemical control is provided by an unusually complete form of spectrograph. A specimen is taken from the molten magnesium by sucking 2 in. or so up into a glass tube with an air gun. This metal is then burned in the spectrometer housing and analyzed as to aluminum, beryllium, copper, manganese, silicon and zinc within six minutes. Tin, zirconium, lead, nickel and iron can also be estimated in this instrument.

It is believed that without such rapid control, the rate of production could not be maintained; therefore the use of the spectrograph is justified, notwithstanding the fact that its purchase price was some $50,000. The instrument does not photograph the spectrum but gives results by direct reading. It is used for traces of elements up to 3%. High aluminum (for instance, 9%) is checked by chemical analysis, although it is expected that even this amount will fall within the accuracy of a modified instrument now being built.

Many specialized foundry operations were shown during the afternoon in Dow's Bay City plant. Space forbids much discussion. Let me comment especially on the amount of careful inspection which is ever present, starting with the precise control of chemical composition of ingot, as just described. Many customers ask for pressure testing and impregnation with a suitable medium using vacuum and pressure alternately. "Zyglo" makes sure there are no fine surface cracks. 100% X-ray inspection is frequently called for; X-rays spot check practically everything. Dimensional measurements usually have to be within very close tolerances.

Foundry production runs about 25 lb. per man per 8-hr. day, and about 4½ lb. of metal is melted for 1 lb. of finished castings. This high ratio is due to the number and size of risers required to cope with the shrinkage of magnesium alloys. H. J. R.

Machinability in Relation to Chips and Lubricants

Study Group 3 ("Fabrication") at Cincinnati Milling Machine Co.

ON A SMALL SCALE, the story of the accomplishments of the Cincinnati Milling Machine Co. is a documentary story of the American machine tool industry, for out of shops such as this have come many of the tools that have paced this nation's manufacturing achievements. Study Group 3 saw not only Cincinnati's facilities and methods, but heard from Frederick V. Geier, president, the technological philosophy on which this and most American concerns are founded.

Essentially, this philosophy stems from a concept that the role of industry in a mechanized society is that of a servant rather than its master; furthermore, through private initiative, vision, and continued development of the tools of manufacture, costs can be lowered to provide greater quantities of better goods for the people of this country and of the world. There are many closely related factors in reaching that goal, but continued development of product is perhaps the most important. This places the responsibility in the lap of research.

Indeed, as a result of the research carried on during the past 40 years, today's milling machines are available with automatic controls and features that permit blind cuts, rise and fall, tracer control, depth control and profiling

—a tremendous contrast with the prototype introduced by Eli Whitney in 1818. However, after the impetus given by the discovery of the method of heat treatment by Taylor and White in the 1890's which produced the high-speed cutting tools, the steady advancement in metal cutting has been due almost entirely to machine development.

Meanwhile, the subject of machinability has received comparatively little scientific attention until rather recently. Although certain rules and principles governing the machining of metals have evolved from practical experience, and empirical methods of testing and analysis have been used for many years, it is only recently that the work of men such as Hans Ernst and Eugene Merchant, Cincinnati Milling Machine Co.'s research director and research physicist, respectively, has concerned itself with the fundamentals of the cutting process and of chip formation.

Much of the information regarding the physical principles involved in the cutting of metals has been obtained through the use of special photographic techniques. Chip formation, chip crowding, chip flow—as well as the behavior of the cutting tool with and without lubricant—are recorded by high-speed movie cameras capable of taking 3000 exposures per sec. The motion picture camera provides an ideal means of studying the influence of tool shape, and sequences have been taken showing the progressive action when cutting at speeds higher than 400 ft. per min.

Ernst has shown that when a metal is cut one of three types of chips is produced, depending on the friction between cutting tool and the chip and on the ductility of the metal being machined:

. Type 1—Discontinuous or segmental chip, formed when the friction is high and the metal is ductile, or when the metal is brittle and the friction is of almost any value.

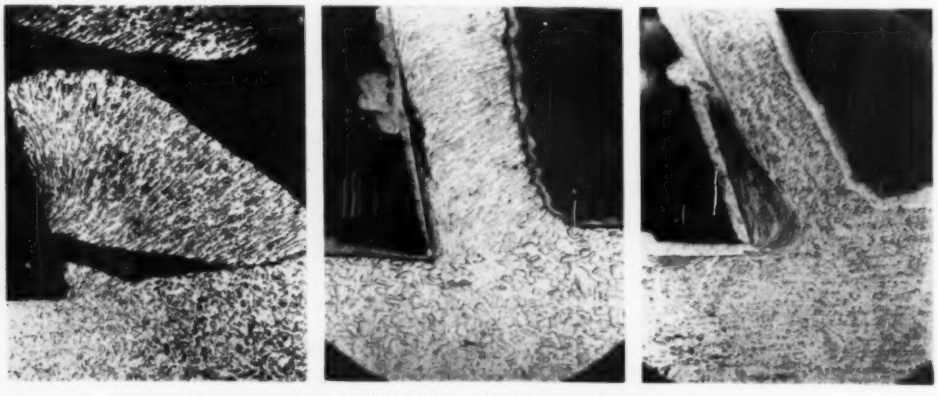
Type 2—Continuous chip without built-up edge, formed when the friction is low and the metal is ductile.

Type 3—Continuous chip with built-up edge, which may be expected when friction is high and the metal is ductile.

The surface finish on a workpiece is influenced by the type of chip formed. The above Type 2 chip provides the best surface; Type 1 chip is next best. Photomicrographs of the three types are shown herewith. Such studies reveal that the cutting process is one of shear and that the process of chip formation is one of plastic deformation. The ease with which a metal may be cut works out to be a direct function of its shear strength.

Another variable that has received considerable study is that of the friction between tool and chip. An important consideration in this respect is the shear angle, or the angle made by the plane of plastic deformation with the direction of travel of the tool. Therefore, if the shear angle is large, resistance to motion of the tool will be decreased because the path along which shear occurs is short. It follows that decreasing the friction angle or the metal's shear strength lowers power consumption, improves the surface of the workpiece and increases tool life.

The wear of tool between grinds is of considerable economic significance, especially in



Micrographs at 40× of the Three Basic Chip Types: I, Segmental; II, Continuous Without Build-Up; III, Continuous With Build-Up

large manufacturing operations. Here again considerable research has been conducted along four lines: The "abrasiveness" of the metal being machined, the power consumed in removing metal, the strength and the heat conducting ability of the tool. Of these, the first is probably of greatest interest to metallurgists.

Ability of the metal being machined to wear away the cutting tool is of two types, inherent and induced. The hard constituents such as carbides, oxides and silicates in the metal being cut are the causes of inherent hardness. Induced hardness is due to the work hardening that accompanies plastic deformation at the time the chip is formed; increases of 300% or more have been observed when comparing chips with the machined surfaces.

According to Merchant, the amount of this induced hardening is mainly a function of the strain hardenability of the metal, of the amount of deformation the metal endures (as related to the shear angle and rake angle), and of the type of chip that is formed. For example, the workpiece of S.A.E. 1112 may have a hardness of 214; the average of the broaching chip (its build-up) may be 477 with a maximum of 548. Furthermore, such a hard built-up edge has a very destructive effect because when it shears from the main portion, it is dragged over the face and flank of the tool.

Another phase of the machinability problem investigated by the research staff of the company is that of the action of cutting fluids. The gist of the findings is that improved tool life and improved finish result if the cutting fluid performs a two-fold function: *(a)* to carry away the heat generated during cutting and *(b)* to reduce friction.

When chips are formed, heat comes, first of all, from the deformation of the metal ahead of the cutting tool to form the chip. That plastic deformation, or shearing of the metal, generates heat. After the chip has been formed it then has to slide up the tool face. As it does so, heat is generated by the frictional resistance between chip and tool. All of the heat produced in machining comes from these two sources; roughly, about 25% from friction and about 75% from deformation of the metal.

Studies at Cincinnati Milling Machine Co. reveal that the friction-reducing action of a cutting fluid bears no relation to its viscosity; it is concluded that this action is not accomplished by fluid-film lubrication. Cutting fluids must, however, possess proper chemical reactivity to form reaction products of a solid film nature at the chip-tool interface to reduce the friction at this point. Providing a lubricant with the desired properties is not an easy task; its reactivity must not be too great or it will attack the work, nor must it react at room temperature or atmospheric pressure but rather at the temperatures and pressures existing at the tool-chip interface.

A lubricant having good friction-reducing characteristics is of considerable benefit at low cutting speeds because sufficient time is available for the reaction to take place. However, at speeds of about 400 ft. per min., at which sintered carbide tools are used, there is practically no time for the chemical reaction. Therefore, good cooling ability is the important quality of the lubricant for such speeds. Both of these properties must be combined in an all-round lubricant — which is quite a problem for the chemist to solve. J. P.

Thin-Walled Bearings

Study Group 2 at
Bohn Aluminum & Brass Corp., Detroit

BEARINGS for aircraft, automobiles, and numerous other purposes form the product of this plant. It is a far cry from the individual sand casting of bearings for heavy machinery — "bushings" or "boxes" with ¼ to ½ in. thickness of babbitt cast on a bronze backing, the whole weighing 20 to 30 lb. (in some extreme cases 300 lb.), to babbitt of 0.005 in. on a thin steel ribbon!

We saw the tinned steel ribbon as purchased from the steel company being coated with 70-30 copper-lead powder, babbitt, and (for aircraft) with silver.

In the manufacture of the copper-lead coating, the steel ribbon is fluxed, the alloy mixture flowed on, and the ribbon passes on through a furnace at a temperature of 1650° F., taking some 12 to 14 min. It is then pressure rolled for uniform thickness, then slit into narrow ribbons according to the width of bearing desired, then to a machine cutting off lengths at the rate of one per second for individual bearings. The pieces then go to the forming die; later they are broached to give a very smooth surface; finally a mirror surface of micropolish is obtained. The accuracy with which each bearing is processed, and the numerous measurements that are constantly made during inspection, certainly insure a finished bearing of the highest [illegible]

Some 342 [illegible] bearings a month are

currently being produced; still the plant was not running to capacity! Some special bearings were being made by casting molten copper-lead into the cylindrical backing around a steel tube core. This core is machined out, thus the bearing metal exposed. Other bearings had the bearing metal centrifugally cast on the backing. The cutting of oil grooves, the chamfering of the ends — all such operations are automatic and speedy to a degree. For example, a plating machine saves the labor of at least five men and operates as though controlled by a mastermind.

We were informed that aluminum alloy will doubtless be bonded to steel plate just as silver and babbitt are today. Certainly the use of such thin layers of bearing metal and thin steel sheet must go far to conserve metal as compared with older methods. H. J. R.

Impressions of the National Metal Exposition

TO DO FULL JUSTICE to the National Metal Exposition would require reference to hundreds of exhibitors; unfortunately, time and space make this impossible.

The Metal Exposition was a suitable climax for the various study groups of foreign conferees that had been visiting numerous cities and plants throughout the eastern United States. Here was to be found products whose origin was from coast to coast — in fact from overseas also.

The excellent quality of the scientific papers had attracted thousands of the members of the American Society for Metals and of the associated organizations. More thousands came from the metal industry of the Detroit region, so that every aisle of the huge exhibition halls was crowded both day and night.

The diversity of products and services was perhaps the outstanding feature, coupled with the new methods that were on exhibition, such as shell molding, cold extrusion of steel, and continuous casting of steel.

The ⊕ metallography exhibit showed to what heights of technique, not to say of artistry, metallographers have risen. It was interesting to note the international character of the photomicrographs submitted.

The presence of top-level executives of the exhibiting firms indicated the sales value placed on the Exposition and the readiness of the companies' representatives to supply reliable technical information, not only to American prospects, but also to the large numbers of our allies. This was certainly gratifying.

One wonders what was the reaction of any communists, for doubtless there were some among the visitors, when they saw the frank attitude taken by all to pool their resources in a common cause, and for the common good.

Any member of the American Society for Metals might well be proud of the part taken by his society in making possible so vast an undertaking. H. J. R.

THE VISITOR making the rounds of the 1951 National Metal Exposition had just about enough time for a peek or two at most of the booths, with opportunity for a longer pause at a few. This was without doubt the largest show of its kind anywhere in the world. It was also the finest and, in light of this country's defense efforts, one of the most important. In view of its very magnitude the following descriptions of some of these measures are, essentially, brief notes of random observations.

The Carboloy Department of General Electric Co. announced its new chromium carbide known as "Series 600", which contains about 70% chromium by weight and none of the strategic metals tungsten or cobalt. It is nonmagnetic, has about the same coefficient of expansion as steel, and although it is hard (80 to 93 Rockwell A) it has ample toughness to grind without chipping or cracking. Salt spray tests reveal that it will withstand a 30% salt solution for 750 hr. It is reported to be completely resistant to oxidation at temperatures up to 1800° F., with favorable results being reported for tests conducted at 2000° F.

Carboloy also has in experimental production a tungsten carbide in welding rod form for hard-surfacing. Bearings of tungsten carbide for use under high speed, load and temperature conditions have been used successfully in test installations. Other advances include cold extrusion of tungsten carbide into various shapes and the hot forming of carbide rod.

As one who had worked with a metallograph that stretched from here to there, the small sized photomicrographic equipment made by Officine Galileo di Milano had a special appeal to me. The ZC Universal model has a base that is about the size of this open book and stands approximately 21 in. high. It is of the table-mounted type with the optical system arranged in a vertical plane. Some of its fea-

tures include magnifications on the ground glass that can be run continuously from 4 × to over 3000 ×, a photo-electric exposure meter and provisions for macrographic work. Another Galileo metallograph displayed in the Opplem Co. booth (American representatives for the firm) was a portable unit that has a base only slightly larger than this page. Viewing is either by an ocular lens or a ground glass screen. The camera portion has no bellows, the photographic image being formed through a special negative ocular located inside the instrument. It uses 2½ x 3½-in. plates or roll film.

Several of the 17 electronic instruments for nondestructive testing made by Institut Dr. Forster of Reuthigen, Germany, were displayed by its American distributor, Magnetic Analysis Corp. of Long Island City, N. Y. One of these instruments is a flaw detector, called "Proboscope", for the inspection of steel parts in production. The part being inspected for surface and subsurface defects is first magnetized and then scanned with a magnetic probe that converts the stray fields at the location of the flaw into electric voltage. The voltage is amplified and can be used to provide a signal on an oscilloscope screen or to light a signal lamp. It can be used for pins, shafts and similar cylindrical objects ¼ to 1½ in. diameter. Testing time is 1 sec. per piece.

"Melters Carbon Test", for determining carbon in steel at the melting furnace in 40 sec., was shown by the Harry W. Dietert Co., Detroit. A specimen 0.0625 in. thick is cast in a water-cooled copper mold, removed in 15 sec., quenched, ground and tested for hardness in a diamond cone hardness tester, and carbon percentage taken off from a correlation table. Accuracy is said to be plus or minus two points in the 0.05 to 0.45% range.

Eldorado Mining & Refining Ltd., Ottawa, Canada, displayed radiographs made with iridium 192 which has a half-life of 70 days and emits gamma radiation of 0.65 Mev, quite suitable for examination of thin components, not exceeding ½ in. for steel and 1 in. for aluminum. In England thulium 170 (doubtless derived from irradiation of natural thulium 169 in a uranium pile) has also been used for aircraft parts inspection. Energy of its gamma radiation is 0.08 Mev, and it has a half-life of 127 days.

Kennametal, Inc., Latrobe, Pa., demonstrated the thermal shock resistance of its Kentanium, a titanium cemented carbide, by alternately heating to 1800° F. and cooling to 180° F. and repeating the cycle every minute while a weight suspended from the wire exerted a tensile stress of 12,500 psi. This substance is made in five compositions, two each with 20% cobalt binder and one each with 10, 20 and 30% nickel, the latter being somewhat superior in high-temperature properties and more ductile. It can be extruded in rods, tubes and flats, molded into simple shapes or, for more intricate shapes, machined from pressed slugs. Uses include inserts for hot extrusion dies, gas turbine propellers, bushings and thermocouple protection tubes.

The vertical slot furnace, a small working model of which was displayed by the Drever Co., Philadelphia, handles bars or tubes that enter at the top, descend through the heating chamber in a horizontal position, and are discharged by conveyer through the end of the furnace. Advantage claimed is fuel economy because the outgoing gases preheat the incoming cold bars. Bars up to 50 ft. long can be handled by such a furnace. The first unit of its kind was placed in operation at Tempered Steel Co., England, about two years ago for the heating of light bar stock which was coiled into helical springs by a machine at the discharge end of the furnace. This furnace, incidentally, was developed by the Incandescent Heat Co., Ltd., England.

From furnaces to fuels is an easy transition. If your plant has ever been faced with occasional fuel gas shortages, Vapofier Corp. of Chicago might meet your needs with its unit that produces enough gas to give from one to four million Btu. per hr. from an hourly consumption of 7½ to 28 gal. of oil. Oil is vaporized in a gas heated chamber, superheated, drawn into the ejector where a little air is added for partial combustion and reforming, after which it is discharged under pressure into the manifold supplying the furnace burners.

Although accelerated tests indicate that its coatings will give protection for relatively long periods, Nox-Rust Chemical Corp., Chicago, had not expected that the products protected with it would be completely submerged in 20 ft. of water or covered with 20 in. of mud and silt. Normally, machined surfaces do not receive this kind of treatment, but this happened during the Kansas City flood and, much to the satisfaction of the company, the "Nox-Rust" coatings served excellently. J. P.

Improved Feeder-Head Tile for Ingot Hot Tops

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In view of the large surface area, complicated shape, and close dimensional tolerances, production of feeder-head tiles has concentrated on the use of fireclay as the material with the greatest adaptability to molding and working. Materials of increased refractoriness, such as magnesite, chromite, dolomite, zirconia or carborundum, are invariably more difficult to mold than fireclay and would involve production difficulties. Apart from the increased cost, the basic and super-refractories are ruled out on account of their greater specific heat and conductivity, which reduce the efficiency of the hot top.

The most frequently used clay in British practice has a 30 to 35% alumina content with low impurities and, in particular, iron below 3% to give a reasonable refractoriness. The more expensive 38 to 42% alumina fireclay possesses a higher melting point yet has a greater tendency to spalling and cracking, and shows no improvement in service.

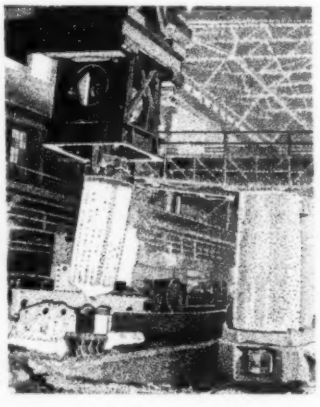
The design of feeder head in which the tiles are destroyed on extraction of the steel ingot, giving a single time of usage, is rapidly becoming obsolete. This is due to a cost of about 70¢ per ton of steel for refractory replacement and labor. Present practice uses a detachable, superimposed feeder-head box which is removed before the ingot is stripped, or the tiles are inserted into recesses in the mold to present a flush internal surface to allow extraction of the ingot.

In both types of practice, the hot top forms a box-like structure approximately 14 x 14 x 12 in. for 1-ton ingots, increasing to 20 x 20 x 15 in. for 4-ton ingots. With the smaller ingots, the tiles are of a sufficient size to form one complete side, but in the larger ingots several tiles are joined together. Manufacturing considerations demand a minimum thickness of 1¼ in. to secure adequate stiffness for handling in the plastic state, and to prevent warping in drying. On the larger ingots, tiles of a 3-in. thickness are sometimes used. Feeder-head boxes for large forging ingots are bricked with standard 9 x 4½ x 3-in. firebricks, or are rammed with a steel molder's mixture.

Feeder-head tiles will invariably withstand eight separate casts; 18 casts in one hot top may be regarded as an exceptional life. For application with 4-ton ingots, a life of ten may be regarded as average, increasing to an average life of fourteen on 1-ton ingots. Generally, failure of a single tile necessitates the replacement of the entire refractories, unless special methods are taken to secure the tiles individually. Assuming an average of 60 min. teeming to stripping time indicates that the refractories are in contact with heat for a maximum period of 18 hr. before failure.

The temperature of liquid steel entering the mold varies between 2550 and 2750° F. as influenced by the carbon and alloy contents, and this temperature is well below the fusion point of the refractory, although some softening of the working face will occur. A thin slag deposit forms on the surface but this is not corrosive and generally there is a tendency to build up.

Failure is due to the detachment of extensive areas of refractory from the surface in the form of laminae approximately ⅜ in. thick. Owing to the rapid heating of the tile by contact with liquid steel, a steep temperature gradient develops at the face. This results in physical changes in the clay, producing a form of vitrification and the development of mullite. Depth of vitrification de-



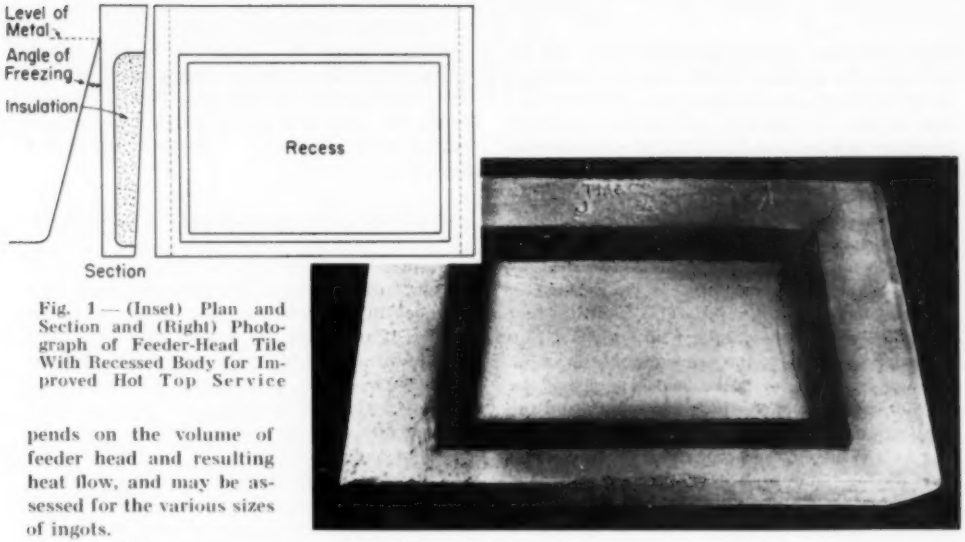


Fig. 1 — (Inset) Plan and Section and (Right) Photograph of Feeder-Head Tile With Recessed Body for Improved Hot Top Service

pends on the volume of feeder head and resulting heat flow, and may be assessed for the various sizes of ingots.

The vitrified area has somewhat different expansion characteristics to the unchanged matrix and, with continuing use, a crack develops parallel with the face at the definite boundary between the two physically different zones. Laminae of vitrified material are detached as a result of the friction developed during stripping of the ingot head. Patching is seldom resorted to because the damage is extensive, and slurrying between heats is considered to be of little benefit.

DEVELOPMENT OF RECESSED TILES

Extensive trials have been made in which the back face of the tile is recessed to leave a working thickness of approximately ¾ in. at the central area, as shown in Fig. 1. The edges have the conventional thickness to assist in manufacture, and to provide a good jointing surface in assembly. The recess will function as an air gap or may be backed with asbestos sheet, or air-setting plastic insulation material. The insulation effect reduces the temperature gradient throughout the section. Vitrification is diffuse and may extend uniformly throughout the section.

In view of the absence of abrupt physical changes, extensive trials have shown a complete absence of spalling, and lengths of life three times in excess of those of conventional tiles have been obtained. Some cracking occurs at right angles to the face after about 15 casts due to the normal stress of thermal reversal, but as the tiles are secured in the head box such cracks are not detrimental and quickly slag over. Eventual failure depends largely on the protection given by the head box or mold casing and the severity of handling.

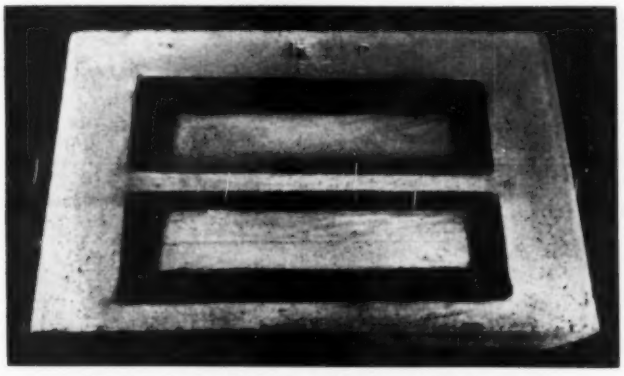


Fig. 2 — Longer Tiles Have Ribs for Added Strength

Correct design to secure the optimum thickness and suitable contour is essential to obtain the best results. On the larger tiles, some degree of strengthening with ribs (Fig. 2) is required, and in view of the ready adaptability of fireclay, considerable versatility of design is quite possible.

An advantage of recessed tiles is that no changes are

required to the ingot mold or head box, and the tiles may be prepared with only the necessary modifications to the molding dies. It is observed that in use the recessed tiles have a reduced tendency to warp and do not break easily during transit. Their decrease in bulk permits speedy handling, and there is a reduction in debris after finally knocking out.

It has been shown that during the solidification period, 90% of the heat is absorbed by the refractory, and only 10% is transmitted to the head box or ingot mold. This indicates that little improvement is obtained by the insulation of feeder-head tiles of the conventional thickness. The important factor is the heat capacity of the hot top, and this is considerably reduced by the application of the recessing principle.

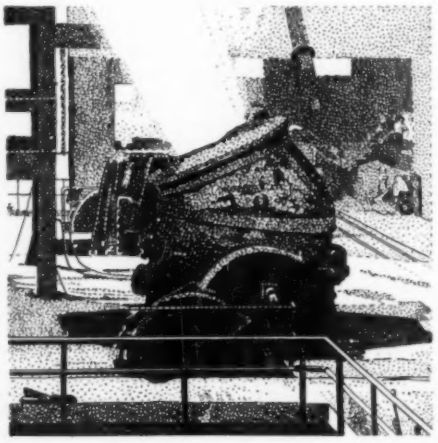
As a result of the progressive drop in metal level during the course of solidification, there is a considerable vertical differentiation in the heat abstraction per unit area on all feeder heads. With square hot tops, this is complicated by the laterial variation due to the corner effect. The provision of recesses may be carried out to give the minimum thickness at the most effective area. Therefore, recessing to prevent spalling is complementary to an improvement in thermal efficiency, but where the latter factor assumes the greater importance, recessing may be controlled accordingly.

The over-all efficiency of hot tops is governed by proportioning to give the minimum surface area for a given volume, which is largely a geometrical problem. Design is influenced by the area available for heat transference to the chill portion of the ingot, and also by the heat loss from the upper surface, which is, however, controllable by the use of inert or exothermic feeding compounds. Attention to the factors outlined introduces the possibility of a considerable reduction in top discard. The new design forms the basis of a patent which the author is taking out in conjunction with Thos. Marshall & Sons Ltd.

APPLICABILITY OF RECESSED FEEDER-HEAD TILES

Porous insulating bricks are being used to an increasing extent in hot tops, and result in a considerable decrease in the volume of feeder head required. The fully insulating bricks are only usable once, but insulating bricks of greater refractoriness may be employed at the expense of some reduction in efficiency. The increased expense and dislocation of production caused by frequent replacement generally precludes the use of insulation bricks from large-scale production.

Recessed tiles are readily applicable to mass production steelmaking without production delays in the change-over. The possibility arises of the application of feeder heads to instances where a balanced steel is used at present.



Bessemer Steel Low in N and P

DESPITE the fact that our translation of Professor Coheur's article on the above subject was submitted to the author for approval before publication, some errors appeared in the printed version (*Metal Progress*, October 1951, p. 78). In three places a steam-oxygen-air blow was mentioned erroneously, whereas a steam-oxygen mixture *without air* is used. Likewise decimal points were omitted in the values for scrap in Table I, reprinted correctly at the right.

Table I — Blows With Enriched Air and Steam-Oxygen

Blow	H_2O-O_2 Mixture	O_2 Consumption*	Scrap Addition†
4 min., 30% O_2 air; 4 min., H_2O-O_2 mixture	63% O_2; 37% H_2O	1350 to 1475	3.4 to 3.8%
	70% O_2; 30% H_2O	1540	7.5%
H_2O-O_2 mixture	63% O_2; 37% H_2O	1765	None
	70% O_2; 30% H_2O	1860	6.0%

*Cu.ft. per short ton pig iron blown; total for entire blow.
†Based on pig iron charged to converter.

Notes on Pyrometry

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INSTRUMENTS for the determination and control of industrial working temperatures usually consist of a measuring circuit and a sensing element. Installation, as well as maintenance of the control instruments, is generally performed by specialized personnel, so that the furnace operators, heat treaters, and others using them need not concern themselves too much with this phase. However, they should handle carefully the sensing elements of temperature measuring devices.

Sensing elements fall into two broad types. One, which includes optical, radiation and color pyrometers, "sights" upon the hot object and attempts to evaluate its temperature from some aspect of the radiant energy received. The other type, which includes thermometers, thermocouples, resistance bulbs and chemical signals, uses what might be called the "touch" or contact method. The latter category, with the exception of the temperature-sensitive coatings, measure only the temperature of their own tips, bulbs or "hot junctions". This temperature is not necessarily identical with the temperature of the object under observation. To insure agreement of the "sensing" element's temperature with that of the workpiece is all-important, and this task must be shared by the installation mechanic and the operator.

The rate of heating and the ultimate temperature reached by an object are determined by the balance between heat input and heat loss. These two factors vary greatly with differences in shape, size, material and position* within the furnace, and they will be significantly different for the thermocouple as compared with the heated object.

The most important source of heat in an electric furnace is radiation from the hot walls. The amount of radiant energy absorbed by a body is proportional to its surface area, but its rise in temperature is proportional to its mass. Usually, the charge has considerably less surface area per unit mass than the couple, so that the former lags behind the latter during the heating cycle. Unless the rate of heating is controlled, this temperature lag may reach several hundred degrees, but will diminish when the rate of heating is reduced to allow "heat soaking" of the workpiece. It is therefore highly important to adjust the heat input to a rate which will permit the workpiece or furnace charge to keep pace with the temperature rise of the couple. The discrepancy during the heating cycle will be increased if an appreciable fraction of the radiant heat is reflected by the surface of the charge, as from a bright or polished object (usually in a protective atmosphere). On the other hand, if the charge consists of a metal of low specific heat, such as aluminum and its alloys, it will heat more readily and will not lag as badly as stainless steel or similar ferrous alloys.

Both the rate of heating and the final temperature of the thermocouple will be decreased if heat is conducted away along the wires of the couple. This heat loss can be minimized by proper installation. An appreciable length of wire behind the hot junction of the couple must be immersed in a zone of nearly uniform temperature; that is, it must not pass through a steep temperature gradient too close to its hot junction. While this is always very important, it becomes even more so when the couple is heavily protected, because the hot junction is then not in intimate contact with the workpiece, but is merely one point in a gradient where the temperature falls from the outer tip of the protection tube to the wires outside the furnace.

Heat exchange between a solid and a gas is very poor if the gas is motionless. Forced circulation or turbulence of the furnace atmosphere will help, to some extent, to even out temperatures throughout the furnace chamber and between the charge and the couple.

However, when a very hot or very cool gas is introduced into a furnace, it will affect the couple more rapidly than the charge, because heat exchange, like radiation, is a surface effect whereas temperature change is a mass effect.

A thermocouple can measure the temperature of the furnace atmosphere only when the latter is drawn rapidly past the hot junction, which must be shielded against direct radiation.

Heat exchange between two solids is good

*When a furnace is first heated, starting from room temperature, heat loss into the outer insulation will be rapid, causing large differences in temperature to exist from point to point within the furnace. No measurements should be attempted until the furnace is "heat soaked".

if they are in intimate physical contact with one another. An excellent way to equalize charge and couple temperatures is to have the couple touch the charge as firmly as possible. (It may even be welded to or peened into the charge.) If all the other necessary precautions are observed, excellent results are obtained in this fashion.

Use is made of this "touch" principle also in contact pyrometry of solid bodies in the open. But here the necessity for a sufficient depth of immersion is not realized — the couple passes through a very steep gradient at the surface of the object, extremely close to the hot junction. Good results can be obtained only if, in addition to making good contact, the hot junction is covered with insulating or reflecting material to prevent rapid loss of heat by radiation from the wires. However, if this insulation is carried too far, the workpiece will lose heat less rapidly at this point than elsewhere and develop a hot spot where the couple is attached. Obviously, to achieve a sufficient but not excessive amount of insulation requires a prior knowledge of what one wants to measure, i.e., the actual temperature.

Some contact pyrometers do not touch the workpiece surface with the flattened hot junction of a thermocouple. Instead, the thermocouple wires, separated a short distance apart from each other, use the metal workpiece surface to complete the electrical circuit. In this type of thermocouple, the hot junction is at the proper temperature at all times because it is a part of the surface of which the temperature is being measured. However, unless the wires are welded to or peened into the surface, it is frequently difficult to insure good electrical contact. Even with recourse to peening or welding, the problem of heat loss due to conduction along the wires still remains as severe as ever. From the foregoing discussion it is evident that a thermocouple well immersed in a liquid or deeply buried in a solid will give the most satisfactory results.

Unfortunately, thermocouples are subject to deterioration by contamination, corrosion and as a result of metallurgical changes brought about by normal use. The subject of deterioration is outside the scope of this discussion, but that possibility should be kept in mind by the operator; if he suspects that deterioration may have occurred, he should request a check by the maintenance department.

Surface-temperature signals of a chemical nature are deposited directly on the surfaces where temperatures are to be measured. They take the form of either a chalk-like crayon mark or a film of paint. Hence they are in excellent contact with the heated surface, and there is no conduction of heat away along any wires. The required amount of these temperature-sensitive coatings is small enough so that they acquire the temperature of the underlying surface almost instantaneously by conduction. At least on metal surfaces this effect is so great that the temperature-sensitive materials remain unresponsive to heat radiation falling directly upon them. Unlike thermocouples, they are not affected by high voltages or static electricity, which makes them suitable for use on electronic equipment, and in induction heating applications. Their principal limitation is that they do not provide continuous readings or permit automatic recording and controlling — as do their mechanical and electrical counterparts.

Total and partial radiation pyrometers utilize the known relationship between the intensity of radiation given off by a hot body and its temperature. Industrial instruments are generally partial radiation pyrometers, because the needs for protecting the sensitive parts of the instrument and for focusing the rays necessitate at least a lens which will absorb part of the radiant energy received. The amount of radiation received depends upon the distance from the hot object (inverse square law) and the emissivity of the surface sighted upon. The instrument reading is lowered by absorption of radiation by intervening smoke and furnace gases which may be invisible but possess absorption bands within the spectral range of the instrument.

In practice, an empirical calibration is made for each specific installation. If black-body conditions can be approximated, or if the required accuracy is modest, an instrument calibrated for black-body radiation is used and allowance is made for the estimated deviation from such conditions. Sometimes the instrument is sighted upon the inside of a ceramic tube which extends into the furnace. This tube is then subject to considerations similar to those previously discussed for a thermocouple.

The various forms of the optical pyrometer depend upon a visual comparison of brightness (energy per unit area) which is independent of distance. Otherwise their characteristics are similar to those of the radiation pyrometers. The color of a hot body is a function of its temperature and is fairly independent of emissivity. Everyone who deals with high temperatures has used color as an indication of temperature in a crude way. Some work has been done along these lines but, so far, instruments based upon this principle have not found wide application.

Fluoroscopic Inspection of Light Metal Castings*

By Justin G. Schneeman
President
X-ray Products Corp.
Los Angeles
and T. E. Piper
Chief Materials and Process Engr.
Northrop Aircraft, Inc.
Hawthorne, Calif.

To determine the actual number of rejectable castings reaching the assembly line as permitted by this recommended practice, as well as to evaluate the effectiveness of fluoroscopy, an analysis was made of 489 lots of castings encompassing 33,777 items. In order to establish some manner of comparison, these castings were inspected initially by fluoroscopic means and then, without benefit of information derived by this inspection, the same castings were subjected to radiographic (X-ray) inspection.

The fluoroscopic inspection revealed that 293 lots contained rejectable castings. Of the 293 quality-deficient lots, 138 had no rejections according to subsequent approved 25% X-ray inspection. In accordance with applicable specifications, these 138 lots would have been accepted and extensive machining and assembly procedures conducted, with the ultimate likelihood they would have been incorporated in airframe structures.

When 100% X-ray was conducted on the balance (not previously radiographically inspected) 318 castings were found to be definitely rejectable. These alarming conclusions invite a choice of alternatives, *(a)* radiographically X-ray 100%, or *(b)* resort to 100% fluoroscopic inspection followed by percentage radiographic inspection. The first alternative would involve a tremendous outlay for equipment expansion, film and manpower. The second alternative would make possible low-cost inspection of a greater reliability than the former as demonstrated by the Northrop survey.

LIGHT METAL ALLOY CASTINGS, in particular aluminum and magnesium, are becoming increasingly important in the construction of present-day airplanes. Demands for heavier load-carrying capacity and increase in speed have brought about the development of light metal alloys for casting purposes and casting techniques far beyond that available for similar applications even in the Second World War. In addition, design engineers have reduced the cross sections of such castings so as to take complete advantage of the inherent additional strength now available in these materials. It is important, therefore, that the internal condition be known of every piece cast of these metals. This assurance of soundness, and thereby safety, can only be proved through proper nondestructive inspection methods, because the part must not be unduly strained or stressed during its inspection.

Many new and worthwhile nondestructive testing methods have been devised to meet the need of proper inspection. One of the methods heavily relied upon during the last war, and even more so during the present emergency, is that of inspection by means of X-ray or radioactive materials. However, we are by no means satisfied that the optimum in X-ray has been reached, nor that this fairly new inspection tool is being used to its full advantage. And, we are not satisfied with the manner in which this tool is used in reducing to an absolute minimum the number of defective castings that might reach the assembly line. We are aware that one defective casting in an aircraft structure can be the cause of a serious accident.

One of the reasons that such a casting may find its way into an assembly lies in the use of the percentage X-ray inspection system for aircraft castings specified in the Handbook of Instructions for Airplane Designers, under the section "Requirements for Structural Castings".

FLUOROSCOPIC EQUIPMENT

Fluoroscopy has definite limitations, and only by realizing these limitations can fluoroscopy be used advantageously. It has been

*This article is based on the authors' paper, "Fluoroscopic Inspection of Light Metal Alloys", presented at the Annual Meeting of the Society for Non-Destructive Testing held in conjunction with the National Metals Congress, Chicago, October 1950, and on data contained in a private report by Mr. Schneeman.

stated that fluoroscopic inspection will give definition on the order of 3%, or less; such statements must be carefully studied, as they are generally based upon the inspection of certain specific materials under certain specific conditions. They certainly do not apply to the inspection of aircraft castings. The question to be answered in the examination of aircraft castings is: "Can we discover rejectable defects in aircraft castings?"

The major limiting factors in fluoroscopy are: *(a)* screen brightness, and contrast of the fluoroscopic image; *(b)* visual acuity and perception of the human eye; *(c)* necessary X-ray power for a given thickness and kind of material, with relation to its source to screen, and screen to eye distance. The screen brightness and contrast are controlled by the type of screen, its grain size, the amount and quality of X-rays reaching the screen.

Theoretically, a large amount (milliamperes) of X-rays will provide for better screen contrast. Increased kilovoltage will result in increased screen brilliancy. Practical application will indicate that the proper proportionate amount of milliamperes and kilovoltage will give the best results. For heavier cross sections, better visual inspection possibilities will be obtained by increasing the kilovoltage of the X-ray instead of using prohibitive amounts of milliamperes. To this date the Patterson Type B, and B Industrial screens have proved to be the best for over-all fluoroscopic inspection of castings. The finer grain screens are not too suitable for castings because of their lower output in brilliancy.

In industrial fluoroscopy, we require continuous and intense radiation at relatively high voltage factors. In addition, the source of radiation, that is, the focal spot of the X-ray tube, must be small so that a reasonably clear image will be obtained. Although extremely high intensity X-ray tubes and generators are not commercially available at this time, certain components of the equipment now on the market will, nevertheless, give excellent results for the purposes intended.

After the X-ray beam has penetrated the part to be examined, enough of this radiation must reach the fluorescent screen to produce a brightness level that is consistent with the limitation of the human eye.

X-ray tubes generating on a continuous basis as much as 25 to 50 milliamperes would be desirable, providing the focal spot were small and the penetrating power were on the order of 150 kv. or better. Since such tubes, to our knowledge, are not available, we had to be content with tubes and generators operating from 6 to 10 milliamperes at the voltage just stated.

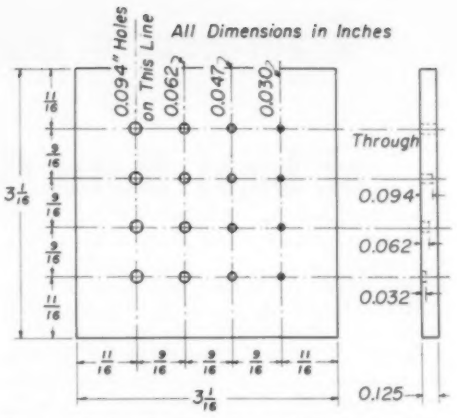

Fig. 1 — Master Penetrameter of Aluminum or Magnesium Used to Check Penetration and Definition

To obtain a high fluorescent brightness level, the distance from the X-ray tube to the fluorescent screen had to be decreased, thus limiting the physical size of the parts that could be interposed between the source of the X-ray and the screen proper. The thickness of the part to be penetrated is largely governed by the kilovoltage available. In spite of all these limitations, it is amazing to note the many parts that are now employed in aircraft structures that can be successfully examined by means of the fluoroscope.

Through actual experience in this field, we find that at approximately 100 kv. and 10 milliamperes with a source to screen distance of not exceeding 20 in., aluminum and magnesium castings can be successfully fluoroscoped providing the cross sections to be examined do not exceed ½ in. This cross-section thickness can be as much as 1⅛ in. if the kilovoltage available is about 150 kv., and the quantity of radiation from 10 to 15 milliamperes. If the part is such that it does not require a 20-in. distance, then a 10-milliampere generator is sufficient, providing the 20-in. distance is reduced correspondingly.

The figures just mentioned are based upon the use of the latest type industrial fluoroscopic screens and direct reading of the image through a sufficient number of clear plates of lead glass without the use of mirrors. Where it is found essential to employ mirrors, the brightness level of the illumination will be reduced about 10% for each front surfaced mirror used in the system. Unless such mirrors are hermetically

sealed to retard normal oxidation, additional reduction in brightness must be anticipated.

A word or two should be said regarding the means that we have provided to enable the operator on the fluoroscope to know whether the parts which he is examining are being completely penetrated, and whether the definition of his fluoroscopic image has as much detail as he believes it has.

For this purpose we have designed a so-called "master penetrameter" similar to the regular run of penetrameters familiar to all industrial X-ray men except that this penetrameter is approximately 3-in. square and is equipped with 16 holes of various diameters and various depths, Fig. 1. The master penetrameter, incidentally, is made of the same material as the part that is being examined and is ⅛ in. thick. It has a row of four holes that are 0.030 in. in diameter, one of which is drilled completely through the plate and the other three are drilled to a flat bottom to, respectively, ¾, ½ and ¼ in. of the thickness of the plate. There are three additional rows of 4 holes each that are drilled in a similar manner except that each set of holes is 0.047, 0.09375 and 0.0625 in. in diameter.

When the master penetrameter is placed in the X-ray beam it should appear clear enough so that at least 14 of the 16 holes are easily discerned; if not, either the operator's adaptation of his eyes to darkness is incomplete, the X-ray equipment is not working properly, or the distance from the screen to the platform supporting the parts is too great. The operator can, at the same time, use the image of the various holes in the master penetrameter to judge the size of similar holes which may appear in the part being examined.

SAFETY

One of the very important aspects of industrial fluoroscopy is that of protection to the operator, especially in direct viewing equipment without the use of mirrors. Adequate protection against stray radiation must be supplied to a much higher degree than is now being practiced in some medical equipment. We must bear in mind that the interpreter of an industrial fluoroscope image is practically continuously viewing the screen similar to viewing a television set and that the entire equipment must be so arranged that no radiation of any kind can reach the interpreter, as well as any other person in and about the industrial fluoroscope.

According to the latest safety requirement as practiced in most atomic laboratories, 50 milliroentgens per day are considered maximum. Once protection is provided for such small quantities, it will be found that with very little additional effort practically all stray radiation reaching personnel can be eliminated.

Industrial fluoroscopy has the one advantage over medical fluoroscopy that the parts to be examined can be placed, if necessary, in a totally enclosed chamber, whereas this is not feasible in medical fluoroscopy.

APPLICATION

Two questions most frequently asked regarding fluoroscopy are, "What can it be used for?" and, "Will it replace an X-ray picture?" The answer to the first question is that it can be used on many things as further outlined. The answer to the second question is definitely "No!"

An X-ray picture, or radiograph so to speak, especially with the various types of film emulsions now available, is optimum in its resolving powers as it can record definitions which in some cases are visible to the human eye only after the film has been enlarged.

A fluorescent image, on the other hand, presents a direct reading medium whose definition is much less than that of an X-ray film but in practical application *so good* (Fig. 2) that it could, under favorable conditions, be almost solely depended upon for the examination of light metal alloy castings.

As a matter of fact, on the majority of light metal alloy castings that are being used in the aircraft industry, fluoroscopic inspection will reveal — with few exceptions — all discontinuities, cavities and cracks of a size that would render such parts rejectable. In other words, an X-ray picture will give more information

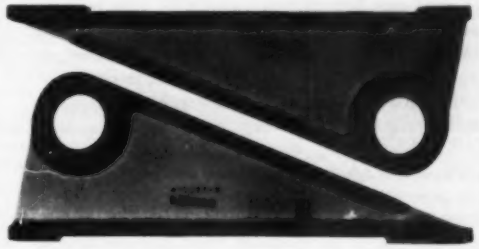

Fig. 2 — Defective Aluminum Alloy Brackets Viewed Through the Fluoroscope Show Cracks Around the Boss

regarding minute discontinuities than fluoroscopy, but when it comes to making a decision as to the usability of a part, then the fluoroscopic image will have provided enough information so that an able interpreter will have the same end result of acceptability as he would have had by radiography alone.

In the present type of X-ray (radiographic) inspection which is now practiced on many parts, the combined use of fluoroscopy and percentage radiography would, of course, give a much superior end result than the percentage radiography alone. In this combination application, no casting with large discontinuities could ever reach the assembly line.

Whatever argument is used to justify today's method, whether it is that of wanting a permanent record, a radiograph of castings inspected, or whether it is the argument of excessive inspection costs or perhaps the argument that fluoroscopic inspection does not give the same high definition of the image as a radiograph, it can be completely disproved by the fact that no record at all exists, in today's system, of the castings not radiographed, and that existing records, consisting of millions of radiographs, are seldom if ever referred to once the radiographic examination has been made.

The over-all cost of this inspection, if properly performed, is less for a complete X-ray examination system as against a present percentage system. (For example, a comparison of the average radiographic cost for pulley bracket No. 509017, bracket No. 413377, rudder pulley bracket No. 414091, and heater intake scoop No. 517757 was 0.81, 1.33, 0.49 and $1.00, whereas the net average combined cost of radiographic and fluoroscopic inspection was, respectively, 0.59, 0.71, 0.25 and $0.31.) The definition provided by modern fluoroscopic equipment is more than sufficient to single out, in accordance with present standards of acceptance, castings having rejectable defects.

Although we occasionally observe the microshrinkage in magnesium castings and fine gas porosity in aluminum castings by means of the fluoroscopic method, it is not at present reliable enough to be used for checking conditions of that type, and radiographic means should be used when such conditions are a determining factor in the acceptability of castings.

We have, however, accumulated enough data to say with certainty that gas holes and other cavities as small as 0.050 in. diameter or 7% (whichever is the larger) of the total thickness of the cross section in which they occur can easily be found by fluoroscopic means. Irregular discontinuities, such as shrink cavities, are somewhat more difficult to observe, and our experience indicates that the smallest ones that can be observed with ease are those which are at least 0.080 in. in their smallest dimension or 10% (whichever is the larger) of the total thickness of the cross section in which they occur.

The data just disclosed take into consideration a certain amount of eye fatigue on the part of the operator because under ideal conditions, as already stated, much smaller discontinuities are visible on the fluoroscopic screen.

Since this discussion concerns itself with light metal alloy castings, we nevertheless want to point out that the fluoroscopic method has also been found ideal in checking the enclosed electrical components in hydraulic valve assemblies, heating coils cast into certain structures and other items of concealed assembly.

We have recently found two additional uses for the fluoroscope that have not been mentioned prior to this time. The first new application is for foundry control which gives the foundryman a method of determining the quality of his own castings at the beginning of each new pour and the second to determine the quality of nonstructural castings prior to machining in order to save machine man-hours on defective castings. The opinion of our quality control division, including the Air Force representative at Northrop, is that the fluoroscope may be used for all screening inspection and the radiograph used on questionable defective castings only.

Fluoroscopic inspection is not intended to replace radiographic inspection but is offered as a supplemental means of rounding out the X-ray inspection so as to more thoroughly analyze at an economical cost many of the items that must receive 100% inspection before they can be used in the airplane.

We are all only too familiar with the film shortage encountered during the last war, and since then photographic and X-ray film is being used on many more applications than heretofore. Therefore, rather than to impair the safety of the airplane by reducing radiographic inspection to a percentage control only, we definitely urge the employment of fluoroscopy wherever and whenever feasible.

EDITOR'S FOOTNOTE: A new X-ray screening tube under development at the University of Chicago produces an image that can be projected on a screen with great clarity and magnification. The use of an exceedingly small target, a special electrical condenser system and a circuit that selects the peaks of the potential applied rather than using an average value of the sinusodial wave permits a 100-milliampere tube to operate at 125,000 volts.

Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

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How SILICOMANGANESE Saves Furnace Time . . . Produces Better, Cleaner Steel

Silicomanganese is used by the steel industry as a furnace block* and deoxidizer, and also for manganese additions.

The cleanness and quality of steel depend largely on how well it has been deoxidized. Deoxidation also greatly influences the physical properties of steel for rolling and subsequent fabrication. Silicomanganese combines two active deoxidizers in a single alloy and it has proved to be a more effective deoxidizer than silicon or manganese alloys added separately. This combination alloy contains silicon and manganese in the correct proportion (approximately 1 to 3.5) to be most effective in reducing the oxygen content of the bath to a low level. The use of silicomanganese produces cleaner steel, saves furnace time, and gives high alloy recovery for manganese additions.

Gets More Oxygen Out of Bath

When silicomanganese is used for blocking and deoxidation, the combined effect of silicon and manganese lowers the oxygen content to a greater degree than silicon alone. This is due to the fact that the amount of oxygen in equilibrium with a given amount of silicon is lower in iron-silicon-manganese alloys than it is in plain iron-silicon alloys, as shown in Fig. 1.

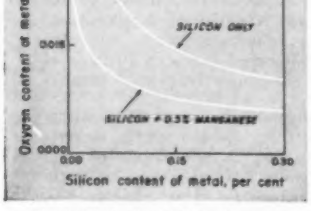

Fig. 1. Limit of solubility of oxygen in iron-silicon alloys, plain and with 0.50 per cent manganese at 1600° C.

*The initial deoxidation of steel, frequently referred to as the furnace block, stops the carbon-oxygen reaction in the furnace. This arrests the carbon drop immediately and makes it possible to secure close control of analysis. If the oxygen content of the metal is reduced well below the level established by the carbon-oxygen reaction, initial deoxidation is accomplished.

Less Inclusions, Cleaner Steel

In addition to lowering the oxygen content, silicomanganese has a specifically beneficial effect on inclusions. The inclusions in a steel depend in large part on how low the carbon content (or how high the oxygen content) is before blocking. The lower the carbon, the dirtier the final steel, almost regardless of the subsequent deoxidation treatment. Since silicomanganese has a low carbon content, it is not necessary to drive the carbon as low (or make the oxygen as high), as when high-carbon or standard ferromanganese is used, so that the final steel is cleaner and has better working properties. The improved cleanliness resulting from silicomanganese is usually noticeable in higher carbon steels, but is outstanding in steels below 0.25 per cent carbon where inclusions and surface defects are a vital problem and where the time saved by blocking at a higher carbon level is significant.

Fast Solubility In Bath

Because of the high concentration of active elements in silicomanganese, less time is required to effect solution of this alloy than when equivalent amounts of silicon and manganese are used separately in the form of ferrosilicon and ferromanganese.

For example, compare these typical analyses of silicomanganese, standard ferromanganese, and 50 per cent ferrosilicon:

	Silicomanganese, %	Standard Ferromanganese, %	50% Ferrosilicon, %
Manganese	66.5	80	—
Silicon	19	—	50
Carbon	1.5	7	—
Iron, approx.	13	13	50

From this it can be seen that 1,000 lb. of silicomanganese would contain 190 lb. of silicon and 665 lb. of manganese. These amounts of silicon and manganese would require 380 lb. of 50 per cent ferrosilicon and 830 lb. of standard ferromanganese, or a total of 1,210 lb. Obviously it is easier and faster to dissolve 1,000 lb. of the combination alloy silicomanganese than 1,210 lb. of these separate silicon and manganese alloys.

Lower Carbon Content

Silicomanganese contains less carbon than any combination of ferrosilicon and standard ferromanganese. Therefore, the carbon-oxygen reaction in the bath can be stopped earlier when silicomanganese is used for blocking. Heats can be blocked at higher carbon levels and hence lower oxygen contents, and the amount of deoxidation required is less.

Fig. 2. Charging silicomanganese into an open-hearth furnace.

Saves Furnace Time

Because of the advantages outlined, silicomanganese can save as much as 20 minutes per melt in the production of open-hearth steel. For low-carbon steel, an even greater saving in time can be realized.

For Producing Engineering Steels

Silicomanganese is also used for alloy additions of manganese, particularly in the production of engineering steels containing 0.10 to 0.50 per cent carbon.

When manganese or other oxidizable additions, such as chromium, must be made to the bath, the use of a block provides a higher alloy recovery. Silicomanganese introduces manganese with the silicon and the usual recovery of this manganese will range from 70 to 85 per cent.

Metallurgical Service Available

Ask to have one of our metallurgists call and explain more fully the advantages of silicomanganese as a furnace block and deoxidizer. He will be glad to help you with the use of ELECTROMET silicomanganese. This alloy contains 65 to 68 per cent manganese and is produced in maximum 1.50, 2.00, and 3.00 per cent carbon grades. All grades are furnished in a lump size of 75 lb. x 2 in. and in a crushed size of 2 in. x down. Write, wire, or phone the nearest ELECTROMET office.

The word "Electromet" is a registered trademark of Union Carbide and Carbon Corporation.

Personal Mention

John B. Johnson

JOHN B. JOHNSON, head of the metallurgy group, Office of Air Research, recently received the Thurman H. Bane Award for 1951, from the Institute of the Aeronautical Sciences. Dr. Johnson was selected as this year's recipient of the award, which is given annually to an officer or civilian of the Air Materiel Command, for his "outstanding contribution in the field of high-temperature materials used in aircraft propulsion units". Dr. Johnson, a pioneer in the application of stainless steel to aircraft construction, began work on the use of high-temperature alloys for aircraft power plants as early as 1930. He was one of the first persons to recognize the potential value to the Air Force of titanium and its alloys. To allow thorough investigation into the structure and properties of ten of the most promising binary alloys of titanium, he initiated work at five separate research laboratories, and during the past year the group under his immediate direction has established over 20 research projects at universities, research institutes, and industrial laboratories. Dr. Johnson first became associated with the Government in 1916 as an airplane and engine inspector for the aviation section of the Army Signal Corps, and he was subsequently appointed aeronautical materials engineer. In 1918 he went to McCook Field, Dayton, Ohio, where he helped to form the nucleus of what has since become the Materials Laboratory of the Air Force. For over a quarter of a century, as chief of this organization, he was responsible for test procedures, and materials and processes used on military aircraft.

G. R. Fitterer

G. R. FITTERER, who is known in the field of research for the development of an electrolytic method for determining amounts and kinds of impurities in steel, the discovery of manganese-silicon alloys now in general use in steel plants, and the discovery and development of an instrument for determining the actual temperature of liquid steel and other metals by direct immersion, has recently been appointed as dean of the Schools of Engineering and Mines at the University of Pittsburgh. He has been professor and head of the department of metallurgical engineering there since 1939. Dr. Fitterer graduated from Rose Polytechnic Institute in 1924 and was subsequently employed as a metallurgist by the American Chain Co., Terre Haute, Ind., and in the company's Stanley Works, New Britain, Conn. After receiving his master's degree in 1927 from Carnegie Institute of Technology on a fellowship with the metallurgical advisory board of the physical chemistry and steelmaking program of the U. S. Bureau of Mines, he remained with the research program until 1931, when he became head of the metallurgy department at the Bureau's Pittsburgh station. During this period he continued his studies and received his Ph.D. degree from University of Pittsburgh. He left the Bureau in 1934 to organize the Fitterer Pyrometer Co., and he became a lecturer in metallurgy at the University in 1935. Dr. Fitterer has been cited by the U. S. Navy for his achievements in the training of steel inspectors during the war, and he was selected as awardee and Campbell lecturer by the American Society for Metals in 1944.

John W. Dunn, formerly vice-president and assistant general manager of Fredric Flader Inc., North Tonawanda, N. Y., has recently joined Bell Aircraft Corp., Buffalo, N. Y., as assistant to the vice-president in charge of manufacturing.

Joseph W. Gray has been appointed division metallurgist for wire at the Joliet (Ill.) Works of the American Steel & Wire Co.

Robert F. Hartmann, formerly plant metallurgist for the gear and axle division of the Chrysler Corp., Detroit, has been appointed to the metal products department of the Research and Development Division, Olin Industries, Inc., East Alton, Ill.

C. Stanley Fergin has recently transferred to the Mead Works Reduction Plant of the Kaiser Aluminum & Chemical Corp., Spokane, Wash., from the Metallurgical Research Division of the company's Trentwood plant.

Edward R. Talone, formerly with Fairchild Aircraft Co., Hagerstown, Md., is now associated with the John P. Clark Co., sales representatives for Ajax Electric Co., Philadelphia, as their Washington, D. C., representative.

John E. Hockett has been working for Reynolds Metals Co.'s Phoenix (Ariz.) Extrusion Plant as senior metallurgist since receiving his M.S. degree in metallurgy from the University of California in September.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

The fact that a Revere Distributor is now celebrating its 125th anniversary year is an indication of the service the company has given its customers through those years. It is also another proof of the essential function performed by distributors for American industry. Most goods, whether industrial materials such as copper and copper alloys, aluminum alloys, iron and steel, or consumer articles such as refrigerators, radio and television receivers, kitchen utensils and ranges, go through the hands of distributors. Generally speaking, only the large buyers are in a position to purchase direct from manufacturers, who do not find it economical to handle the smaller orders. Yet those orders when pooled in the hands of an organization set up to handle them attain sizable totals, and hence a good distributor account is exceedingly attractive to a large manufacturer such as Revere.

A distributor serves not only the factories from which he buys. He also performs an invaluable service to his customers by making quickly available to them the products they require. A machine shop, for example, may need only a few hundred pounds of brass rod; there is a distributor within easy reach who can furnish it almost immediately. Or a contractor may want a few pieces of steel pipe and a thousand feet or so of copper water tube. Again, the distributor has them. A metal products distributor has to carry such items and an infinite number of others. The Revere Distributor who started in business 125 years ago actually has in stock 53,000 different items, cataloged, indexed, and held in warehouses ready for immediate shipment throughout its territory. Each month this stock is drawn upon by 5,000 to 8,000 customers, each order relatively small. There are many Revere Distributors with similar stocks and offering equal service.

To keep this distributor's warehouses filled with a balanced inventory, 18 people are required in his purchasing staff, which includes specialists in various kinds of materials, machines, tools and supplies. And to serve customers with information, quotations and the like, 25 salesmen are on the go constantly, calling on manufacturers, contractors, builders and stores throughout the busy industrial area in which the distributor operates. The large business done by the company is in great contrast to that of 125 years ago, when it was little more than a hardware store. The enterprise has grown in the American tradition of freedom to prosper in accordance with the principles of reliability and efficiency, fair dealing and integrity in performing a desired function.

Revere Distributors are selected for their ability to serve, and also chosen as to location, so that no matter where you are in this big country of ours, there is a Revere Distributor within easy reach. Today metal stocks may be short due to defense demands but manufacturers are doing everything possible to keep distributors supplied.

If you buy from distributors we suggest you remember that they are not only "central stockrooms," but have a great deal of special knowledge about the products they sell and can give you much helpful advice. Not only that, through the Revere Distributors you can be put in touch with the Revere Technical Advisory Service, which will cooperate with you on matters concerning the selection and fabrication of the Revere Metals. Our distributors, and those of every other manufacturer, render many essential services, both to those to whom they sell, and to those from whom they buy. The distributor system as it operates in the United States arose in response to the need for it. Today it fulfills that need more effectively than ever before.

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Personals

Lloyd R. Jackson has been named an assistant director of Battelle Memorial Institute, Columbus, Ohio, and will handle research coordination. Mr. Jackson is known for his work on the engineering properties of metals. He has been associated with much of Battelle's research on fatigue, creep, plastic flow, and structural analysis, and he is the author of several technical papers.

Zay Jeffries, director-general of the World Metallurgical Congress, has been made an honorary member of the Japanese Institute of Metals, an organization which is comparable to the American Society for Metals. Dr. Jeffries is the seventh person ever to be given such a membership, and he is the first since World War II. Presentation was made by Tokusbichi Mishimi, professor of metallurgy, University of Tokyo, who was the leader of the 20-man Japanese delegation which attended the Congress.

M. E. Holmberg has recently opened a consulting metallurgical service office in Houston, Tex. For the past 15 years he had been associated with the Phillips Petroleum Co., Bartlesville, Okla., where he had served as manager of the test division for 10 years.

Victor Caron, of Ottawa, Ont., has just returned from France where he obtained his engineering degree at the Ecole Superieure de Soudre Autogene, Paris.

A. W. Winston has recently been appointed assistant manager of the magnesium department, Dow Chemical Co., Midland, Mich.

Rockwell Manufacturing Co. has recently acquired the Barberton (Ohio) Division of Pittsburgh Valve & Fittings Corp., and has appointed **Hans J. Heine** to the position of chief metallurgist. He will also continue in charge of the metallurgical work of the Pittsburgh Equitable Meter Division in Pittsburgh. Operations in Barberton include the casting and finishing of gray and malleable iron as well as nonferrous alloys for the Rockwell line of lubricated plug valves.

Lindberg Steel Treating Co., Chicago, has made the following appointments at their Chicago plant: **E. J. Pavesic**, director of research, **N. O. Kates**, works metallurgist, and **F. J. Minch**, metallurgist.

John F. Kahles, formerly associate professor of metallurgical engineering at the University of Cincinnati, chairman of the ASM's Educational Committee and past chairman of the Cincinnati Chapter, is now a partner in Metcut Research Associates, Cincinnati, doing research, testing and consultation in metallurgy and machining. He will continue to direct research in the Metallurgical Engineering Department of the University's graduate school as research associate.

Glen W. Wensch, formerly with the Los Alamos Scientific Laboratory, Los Alamos, N. M., is now employed with the Fansteel Metallurgical Corp., North Chicago.

Frederick C. Langenberg, a June graduate of Lehigh University, has been employed by the research laboratory, United States Steel Co., Pittsburgh.

C. E. Rawlins has been named manager of the test division, Phillips Petroleum Co., Bartlesville, Okla. He has been with the company since 1937.

H.S.S. Hardening
The Sentry Way!

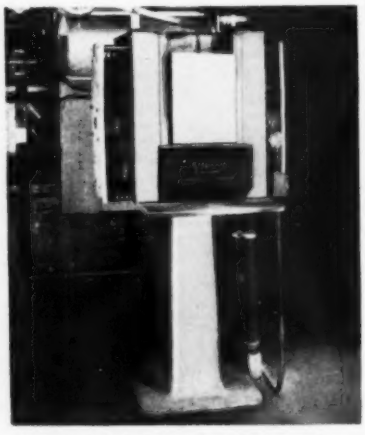
Sentry
"Always on Duty"

Increases Tool Life at JENKINS BROS.

The producers of world-famous Jenkins Valves find countless daily jobs for their hard-working Sentry Furnace.

They have proved to their entire satisfaction that H.S.S. Hardening The Sentry Way is the most efficient and economical way to heat treat the high speed milling cutters, taps, form tools, reamers and other cutting tools used for machining their brass, bronze or stainless steel parts.

Ask for catalog A-6.



Sentry Model 4Y at Jenkins Bros., Bridgeport, Conn.

Sentry Model YP. Vertical model for long, slender drills, broaches, reamers, etc.

Sentry Model 2Y. For small tools, cutters of moly, tungsten and cobalt high speed steels.

The Sentry Company
INDUSTRIAL ELECTRIC FURNACES AND EQUIPMENT FOR HEAT TREATMENT OF METALS
"Always on Duty" FOXBORO, MASSACHUSETTS

NU-SAL AND THERMO-QUENCH ... two Park *laboratory controlled* heat-treating salts that make an unbeatable team on interrupted quenching operations!

Nu-Sal, you know, possesses unusually high thermal-conductivity. It provides rapid, uniform heating that assures consistently good results and its working range covers the hardening temperatures of most commonly used steels. In addition, you'll find that Park Nu-Sal forms an exceptionally fluid austenitizing bath of great fluidity and miscibility.

Thermo-Quench is a more recent Park development made especially for interrupted quenching, transformation and tempering operations. It has a low melting point .... 290°F. ... and it forms an extremely fluid bath that provides desirable cooling rates through the critical zone.

For specific application recommendations on these and other Park laboratory controlled heat-treating products, consult your nearest Park Service Representative or send us full particulars direct.

New NEUTRA-GAS PROCESS*
FOR MAINTAINING NEUTRALITY OF CHLORIDE-BASE SALT BATHS!

● Latest development of Park's research laboratories is the new Neutra-Gas Process ... a simple, efficient, economical method of maintaining absolute neutrality in chloride-base salt baths. Suitable for use between 1350° and 1950° F., the new Process completely eliminates objectionable oxides simply by periodically passing small amounts of harmless gas through the molten salt.

No rectifiers are required ... sludging is eliminated .... and no fresh salt additions are needed except to replace drag-out. Further, the Process maintains original fluidity of the bath and work leaves as clean as when it entered. Write today for our Technical Bulletin No. H-25. It tells the whole story.

Park
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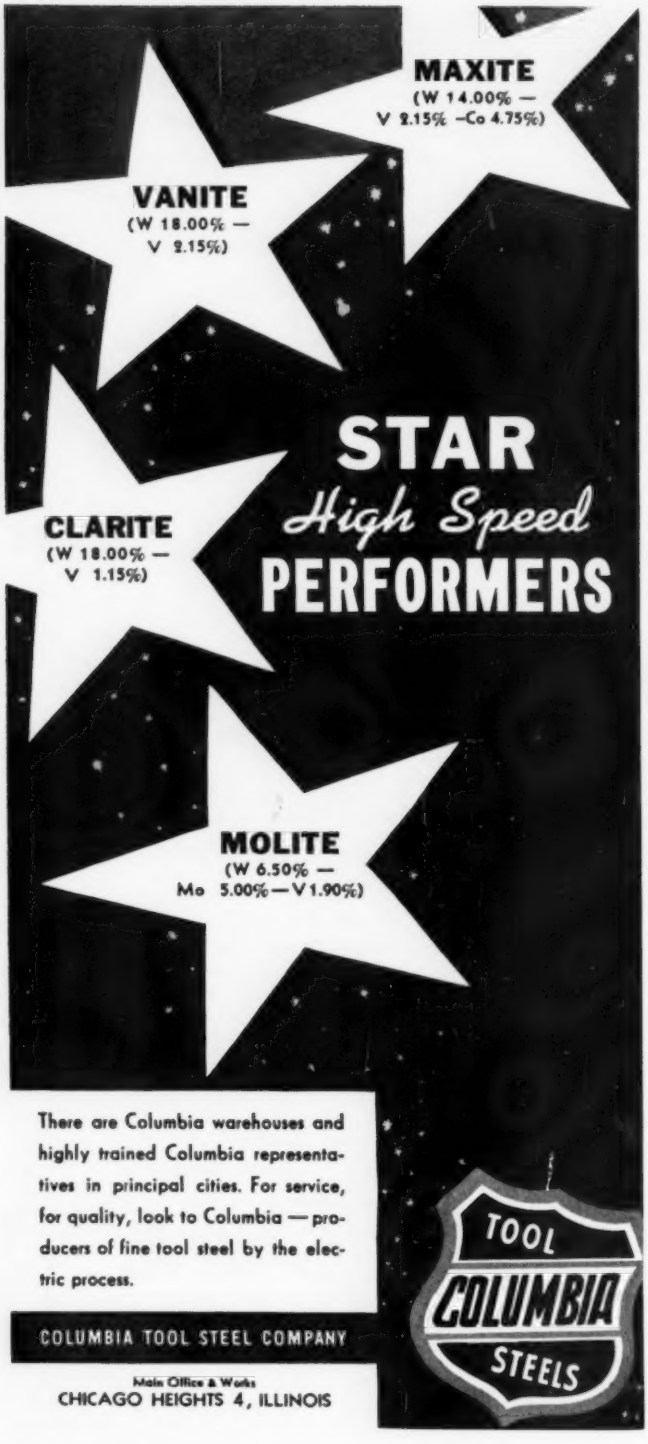
* U. S. PATENT #2474680



Personals

A. C. Woolley has been appointed manager of the industrial division of the Pacific Scientific Co., San Francisco. He formerly operated the Woolley Instrument Service, Inc., Portland, Ore.

Richard A. Flinn, assistant chief metallurgist in American Brake Shoe Co.'s Research and Development Center, has accepted an associate professorship of product engineering and metallurgical engineering at the University of Michigan. He will also be in charge of the University's experimental foundry. He will leave his present position near the end of this year but will retain connections with the company as a consultant. Mr. Flinn received the Howe Medal of the American Society for Metals in 1944, and in 1947 he was the recipient of the Peter L. Simpson Memorial Gold Medal for his technological contributions to the foundry industry.

Alan Goldblatt and Melvin A. Robin, consulting engineer, have formed the Metallurgical Instrument Co., Chicago, which will act as distributors for the metallurgical and optical instruments manufactured by Officine Galileo, Milan, Italy.

Battelle Memorial Institute, Columbus, Ohio, has recently promoted three of its research staff to supervisory positions. **Arthur D. Schwope**, who specializes in physical and mechanical metallurgy, has been made supervisor of research in mechanical metallurgy; **Henry A. Saller**, who has been associated with Battelle work for the Atomic Energy Commission, has been made supervisor of research on special metallurgical materials; **Charles F. Lucks**, a physicist, who has been with Battelle since 1930, was appointed supervisor of the Institute's instrument division.

Arch Horner, formerly with Austenal Laboratories, Inc., Chicago, is now director of sales and advertising for Casting Engineers, Inc., Chicago.

Randolph D. Zonge has resigned as chief metallurgist of the Lycoming-Spencer Division, Arco Manufacturing Corp., Williamsport, Pa., to accept a position in the metallurgical department, White Motor Co., Cleveland.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

How the Right Steel Solved These 3 Tool Problems

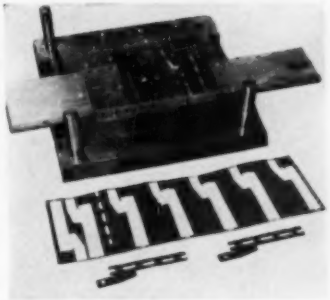
Our metallurgical servicemen and distributors are constantly on the job to help users get the most out of their tool steel. Here are the highlights of some recent tool problems solved by selecting a more suitable steel.

A MAKER OF AUTOMOBILE BUMPERS had been getting poor service from shear blades for trimming hot-rolled spring steel. High-speed steel didn't wear long enough and the cutting edge peened. High-carbon, high-chromium tool steel (our Lehigh H) was tried next. It had plenty of wear-resistance, but the cutting edges developed chipping trouble. **SOLUTION:** Our man suggested Lehigh L (a high-chromium grade with lower carbon). This worked fine — because it had sufficient wear-resistance combined with more toughness.

AN AIRCRAFT FIRM WAS BOTHERED by the cracking of some special wrenches for assembling aircraft parts. The wrenches had very sharp corners, and both thin and thick sections. The application called for plenty of toughness and a fair amount of wear-resistance. The firm had been making these wrenches from a low-carbon type of silico-manganese tool steel, and they were cracking in the water-quenching operation. **SOLUTION:** We recommended Omega. With its less drastic oil-quench and inherent toughness, it has licked the cracking trouble.

A SHEET-METAL FABRICATOR COMPLAINED to a Bethlehem salesman about the premature breakage of small-diameter punches. Rather long and slender, the punches were used on sheet steel of greater thickness than the punch diameter. (It's usually best for the punch diameter to be greater than the thickness of material being punched.) The punches were subjected to excessive side thrust; constant breakage was running up production costs. **SOLUTION:** They tried 67 Chisel, our chrome-tungsten grade of shock-resisting tool steel. Result: Punches produced about eight times as many blanks as previously.

Die turns out 500,000 pieces . . . and still going strong



This progressive die, made of BTR, performs a perforating, notching, and blanking operation in the production of condenser brackets. This popular grade of oil-hardening steel was selected by the user because it's easy to heat-treat . . . it has good resistance to distortion in heat-treatment and it's easy to machine.

The long-wearing qualities of BTR are evidenced by the production of more than a half-million pieces at the time the photograph was made. Hardened to Rockwell C-59, it produces about 30,000 parts from 3/32-in. steel strip before redressing is needed.

Our Tool Steel Engineer Says:

Rapid wear is caused usually by improper heat-treatment

When tools fail by wearing too rapidly, the trouble can usually be traced to inadequate heat-treatment resulting in decarburized surfaces, improper quenching that produces low hardness, and other faulty procedures.

However, poor wear-resistance may also result from the use of the wrong type of tool steel. If a blanking die is made of a 0.60 pct carbon steel of the shock-resisting type, it can't be expected to wear as long as a 1.50 pct carbon steel having a high chromium content.

NEW USE FOR HIGH-SPEED STEEL

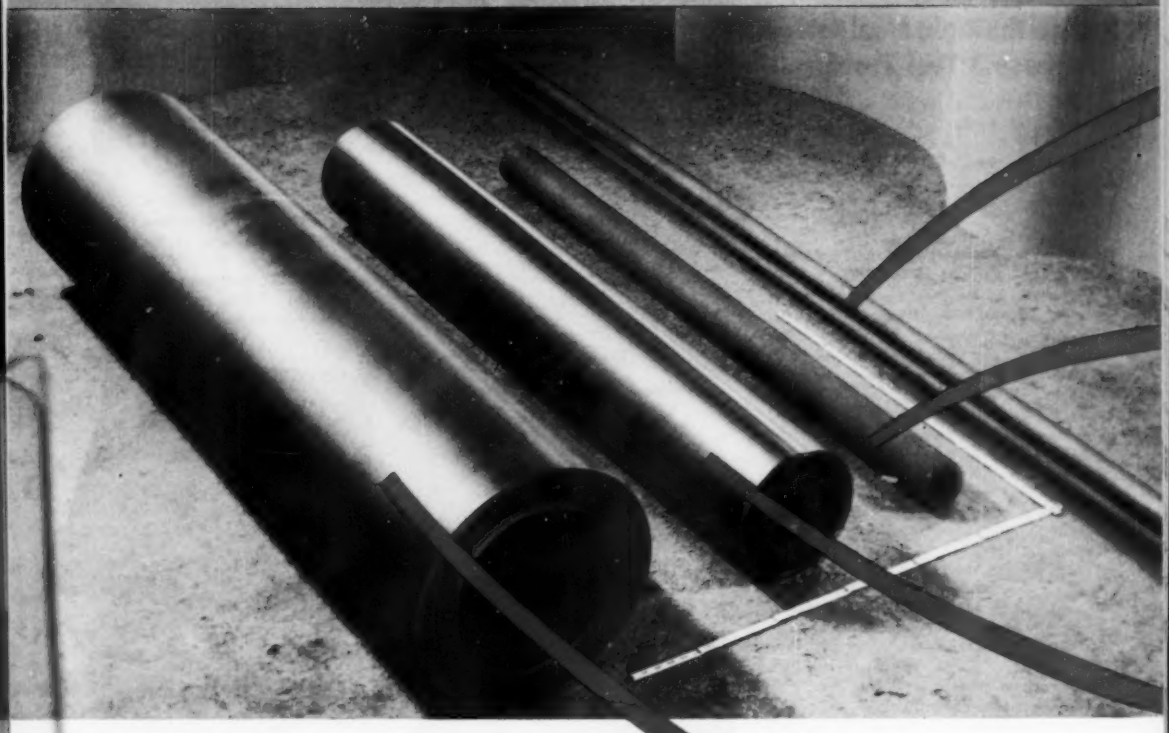
An enterprising apprentice in a tool shop stumbled on a small cache of round steel bars the other day. They were just the right size he needed for a small storage rack the foreman had asked him to build. He made a nice job of it. "This ought to make a hit with the foreman," he thought as the last bar was fitted into place.

When the foreman took one look at the rack, he recoiled in horror. "Oh, no!" he groaned. To the puzzled apprentice the foreman growled, "Young fella, that rack you've got there is worth about ten times the cost of the carbon steel bars it's going to hold. Looks like you've used up every piece of my high-speed steel."

Bethlehem ULTRASONIC TESTED **Tool Steel**

quality + economy

YOU ARE SURE OF BOTH WITH THE VERSATILE METAL MOLD PROCESS



Rarely does a process as new, relatively speaking, as Metal Mold Centrifugal Casting score so many outstanding successes in so short a time . . . and in such varied fields of application. This remarkable acceptance is probably due, in great part, to its unusual versatility.

These applications cover a wide range of cylindrical products in gray and alloy iron, as well as carbon, low alloy and stainless steel. Four typical uses in gray and alloy iron are shown at the right.

Regardless of the end use, one factor remains constant: high quality at low cost. Metal soundness, uniform wall thickness, ease in machining, and broad size range are assured when you specify Metal Mold Centrifugal Casting.

We have a brochure describing the uses and possibilities of Metal Mold Centrifugal Casting which many engineers and production men have found valuable. If you would like to have a copy, write us here in Burlington.

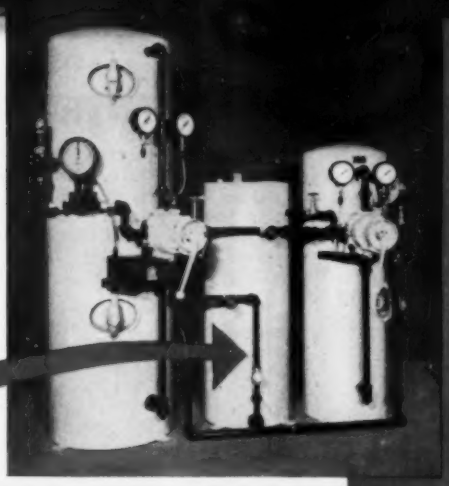
UNITED STATES PIPE & FOUNDRY CO.

SPECIAL PRODUCTS DIVISION — USP

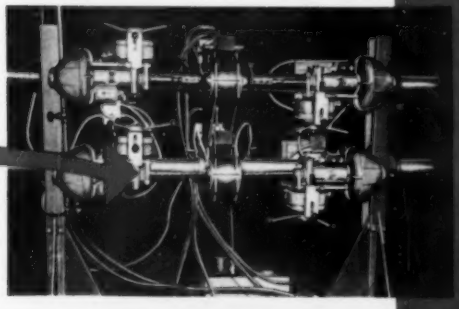
Special Products Division

BURLINGTON, NEW JERSEY

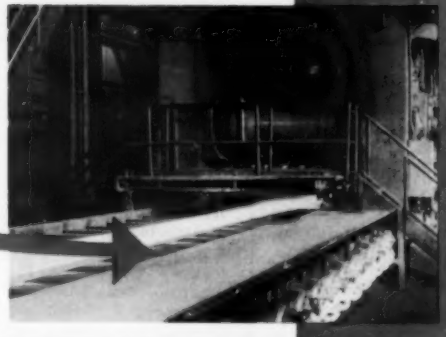
AMERICA'S LARGEST PRODUCER OF CENTRIFUGALLY CAST FERROUS METAL PRODUCTS IN TUBULAR FORM



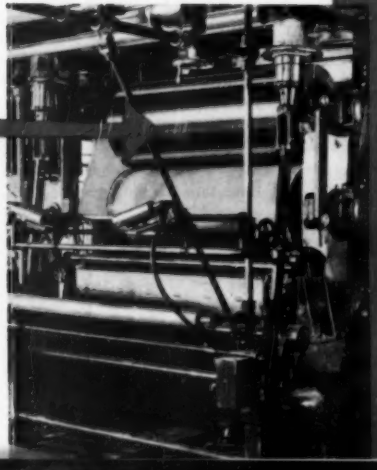
CONCENTRIC, SOUND AND EASILY MACHINED— The lower range of casting sizes for the versatile Metal Mold centrifugal casting process is illustrated by the small iron tubing (1½" IPS) used in this popular Inversand Water Filter and Softener (courtesy Hungerford & Terry, Inc.). The excellent concentricity, soundness and uniformly good machining characteristics make this iron tubing most useful for processing equipment. Considering the relatively low cost, it exemplifies "quality with economy".



CLOSE DIMENSIONAL CONTROL AND SOUNDNESS— The columns of this machine—a combination of 4 standard Walker-Turner 20" power feed drill heads—(courtesy Walker-Turner Division of the Kearney & Trecker Corporation) typify the close dimensional control and soundness obtainable with Metal Mold centrifugal castings. These straight, close-grained cast iron columns offer many advantages—good damping properties, high compressive strength, freedom from "hard" and "soft" spots and machinability reportedly 20% better. Prices are competitive.



TAILOR-MADE TO STAND UP LONGER—The miles of steel carried by the centrifugally cast run-out table rollers in this Hot Strip Mill (courtesy United Engineering and Foundry Company) call for a "tailor-made" alloy iron capable of taking the shock, wear and abrasion that continuous service demands. The Metal Mold process provides table rollers that meet all of these severe requirements.



MOST EFFICIENT AND ECONOMICAL WHERE MASS AND WEIGHT ARE "MUSTS"— Padder and squeezer rolls of the type illustrated in this three-roll heavy duty padder (courtesy Morrison Machine Company) are made of gray iron and represent the upper range of the Metal Mold centrifugal casting process. In applications of this nature, where mass and weight are required, no other material can do the job as economically and as efficiently as gray iron.

yes...

G. O. Carlson, Inc. has built its reputation over the years by saying "yes" to users of stainless steel plate items—and by delivering chemical quality stainless to the precise requirements of industry . . . on time, as promised.

Today, our expanded specialized facilities are enabling us to say "yes" to a great diversity of critical requirements. Our entire production and scheduling are so organized that every usable pound of stainless steel is made available for the present emergency without waste.

Saying "yes" is much more involved than it has been for a number of years. When we can say "yes", we mean it.

Stainless steel is our only business . . . and we know it.

G. O. CARLSON, INC.

Stainless Steels Exclusively

300 Marshalton Road, Thorndale, Pa.

PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)

District Sales Offices and Warehouse Distributors in Principal Cities

Personals

Martin L. Killgallon ⊖, superintendent of Division I, Oliver Iron and Steel Corp., Pittsburgh, has recently been named plant manager of the company's Berry Division, Corinth, Miss.

George Medley ⊖ has been employed by the Alloy Engineering and Casting Co., Champaign, Ill., as an assistant to **Walter Edens** ⊖, Defense Projects Executive, on engineering and development and pilot production activities. Mr. Medley, formerly a metallurgist at Hughes Aircraft Co., Los Angeles, designed the tools and supervised the production of molds and castings for the compressor of the small Boeing gas turbine used to operate auxiliaries on aircraft and currently functioning as a power plant in motor trucks.

Carl Wagner ⊖, visiting professor of metallurgy, Massachusetts Institute of Technology, has recently received the first Palladium Medal Award of the Electrochemical Society. The Medal, established in 1950 by the Corrosion Division of the Society, was presented to Dr. Wagner for his "outstanding achievements in the study of corrosion of metals and its control".

David Goldberg ⊖, fomerly senior metallurgist with the Hamilton Watch Co., Lancaster, Pa., has been employed as a metallurgist by Westinghouse Electric Corp., Lester, Pa.

Ralph E. Bates ⊖ has transferred from Procter & Gamble Manufacturing Co., to the Procter & Gamble Defense Corp., at the Pantex Ordnance Plant, near Amarillo, Tex., where he is chief engineer.

Donald E. Nulk ⊖, formerly research assistant at the University of Maryland, has accepted a position as resident chief metallurgist at Solar Aircraft Co., Des Moines, Iowa.

Robert H. Aaron ⊖ and Samuel L. Sola have formed a new company, Larad Engineers, Culver City, Calif., for the purpose of rendering an engineering design and development service to industry in the Western area.

Theodore B. Wilk ⊖ has recently accepted a position as chief metallurgist for Erico Products, Inc., Cleveland.

...to increase production per unit and per man"

"It must happen in a lot of shops. When a variety of metal working and metal cutting operations are involved, it's easy for the lubrication guides and the metal cutting requirements to get out of date. In our case, the outmoded requirements resulted in serious curtailment of per unit and per man production.

"We experimented quite a lot on our own but finally called in a Cities Service Lubrication Engineer. In an amazingly short time he diagnosed our trouble. Then he set up an air tight schedule. It was easy to follow. It cost no more and the production results were immediate. This man knew his business. Our new production figures are definitely something to brag about."

Why not let a Cities Service Lubrication Engineer look over your operation. His service is free and the products he recommends are—absolutely—the best available on the market today. Get in touch with the Cities Service representative nearest you for lubrication advice and recommendations—or mail coupon below.

FREE...
Fact-filled
New Booklet
For the Metal
Machining Industry

CITIES SERVICE OIL COMPANY
Sixty Wall Tower, Room 20
New York 5, New York

Please send me without obligation your new booklet entitled "Metal Cutting Fluids."

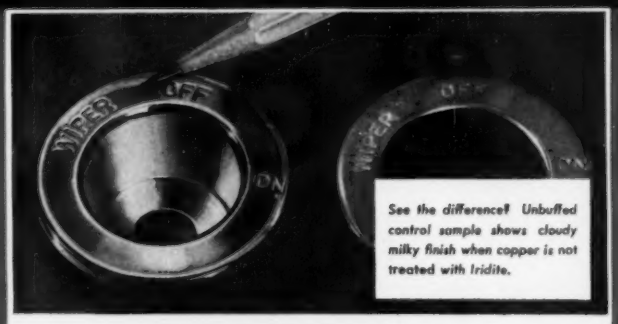
Name_____

Company_____

Address_____

City_____ State_____

LOOK— what you get WITHOUT BUFFING



See the difference! Unbuffed control sample shows cloudy milky finish when copper is not treated with Iridite.

with IRIDITE® Metcote in COPPER-CHROME FINISHING

This sparkling bright finish is the result of just a simple dip in Iridite Metcote between the copper and chrome plating cycles! You actually get the clear, bright appearance of copper-nickel-chrome because the Iridite treatment gives maximum brilliance and clarity to the copper undercoating.

FORGET BUFFING COSTS, PR PLATING! Once you've properly prepared the base metal . . . steel sheet or zinc casting . . . you can completely forget buffing costs because no further buffing is required! And, there is no need to resort to PR plating or extra brightener in the copper plating solution because of the chemical polishing action of Iridite Metcote. The result? A pleasing clear, sparkling bright finish that is ideal for decorative products.

PROVE IT YOURSELF! Send us samples of your product for test-processing with copper, Iridite Metcote and chrome. Then make your own inspection and tests. Once you've seen your own product treated with this Iridite finishing system you'll never go back to slower, more costly buffing for your bright finishing. Start saving money *now*—write us direct or call in your nearest Iridite representative. Look under "Plating Supplies" in your classified telephone directory.

Iridite is approved under government specifications.

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REPRESENTATIVES IN PRINCIPAL INDUSTRIAL CITIES; West Coast: S. H. BUTCHER COMPANY
Manufacturers of Iridite Finishes

Personals

Richard H. Haupt, a June graduate from Pennsylvania State College, is presently taking the training course in secondary metals refining at the Federated Metals Division of the American Smelting and Refining Co., Whiting, Ind.

H. J. Hueston, who has been associated with naval aviation for over 30 years, has returned to the Philadelphia area for duty with the Navy's Technical Division of the Aviation Supply Office.

P. G. Bastien was elected president of the International Committee on Testing Cast Iron at the last International Meeting of Foundry, Brussels, Belgium, in September 1951.

Daniel L. Wertz has been appointed vice-president in charge of sales by Dow Furnace Co., Detroit.

Ira S. Young, formerly engineer of tests in the research department, National Malleable and Steel Castings Co., Cleveland, has accepted a position as metallurgical engineer with Cooper Precision Products, Los Angeles.

W. L. Thompson, Jr., has taken a new position as branch manager of the Tool and Die Supply Division, D. J. Andrews, Inc., in their Buffalo, N. Y., office.

Joseph F. Cerness, senior metallurgist, and **Wilbert H. Morrison**, senior metallurgist, have been promoted to chief metallurgist, and assistant to the director of research, respectively, in Cleveland Graphite Bronze Co.'s Engineering Division, Cleveland.

Percy C. Jones has resigned his position as metallurgist for the Production Foundries Division, Jackson Industries, Inc., Birmingham, Ala., to become a metallurgist for Rheem Manufacturing, New Orleans.

William Nighman has been employed in the research and development department, Reynolds Metals Co., Listerhill, Ala., since his graduation from Purdue University in June.

William R. Holman has been employed by Stanford Research Institute, Palo Alto, Calif., as a physical metallurgist.

They aren't worried about steel...
BUT A LOT OF PEOPLE ARE

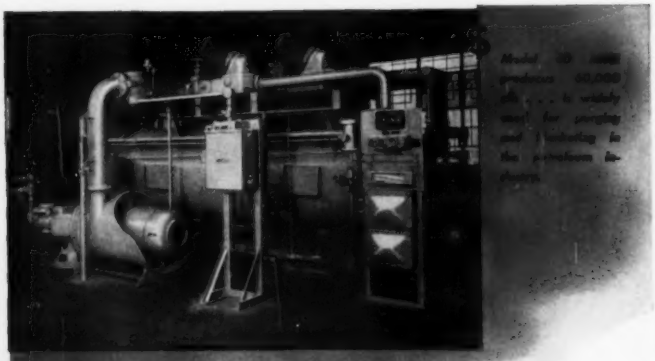
Honestly, we don't like it any better than you do. We're in the steel business to fill the orders of our regular customers and go out looking for more. And we just can't do it in these times.

You know the steel situation as well as we do. Our mills are producing every ton of steel to capacity—and we still can't make it go all the way round to all the people who want it.

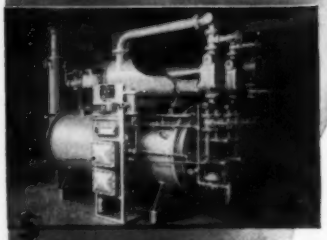
But we can and will continue to produce steel as fine as strict metallurgical control can make it. And we can and will continue to be completely honest about our ability to deliver. When we promise shipment, you can rely on that commitment, in the specifications and with the quality you always expect from us.

WISCONSIN STEEL COMPANY, affiliate of INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue, Chicago 1, Illinois

WISCONSIN STEEL



Why Pay Premium Prices For Inerts?



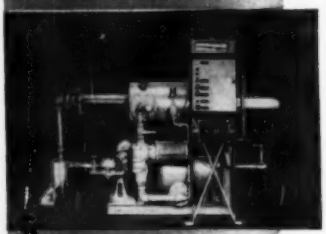
Model 4 MIKE is ideal for agitating, bubbling and blanketing in synthetic resin plants . . . delivers 6000 cfh.

KEMP Inert Gas Producers Can Save You up to 90% on Inert Gas Costs

Whether you now use bottled inerts or produce them with old-fashioned equipment, switch to a Kemp Inert Gas Generator and save 83% to 90% on your inert gas costs. Kemp Inert Gas Producers and Kemp Nitrogen Producers are available in standard models with capacities ranging from 500 to 200,000 cfh for fully automatic operation.

ABSOLUTELY DEPENDABLE

No matter what the demand, Kemp Inert Gas Generators give you the same analysis Inert Gas from 20% to 100% of capacity. The Kemp Industrial Carburetor, part of each installation, burns ordinary gas just as it comes from the mains. Assures complete combustion without "tinkering." Produces a clean, chemically inert gas to meet your most exacting requirements.



Model 1 MIKE offers all the features of larger equipment . . . delivers 1000 cfh . . . is fully automatic.

SEND FOR DATA

Whatever your requirements, always specify Kemp. *To find out how you can benefit:* Tell us your atmosphere gas problem, and we'll show you how Kemp can solve it and save you money!

KEMP OF BALTIMORE

INERT GAS GENERATORS

Write for Bulletin I-10 for technical information.
C. M. KEMP MFG. COMPANY,
405 E. Oliver St., Baltimore 2, Md.

Personals

R. M. Peterson has been assigned to the Production Department, U. S. Naval Shipyard, Brooklyn, N. Y.

Saul E. Bramer, who graduated from the University of California in June, has been employed as a metallurgist with the California Research and Development Co., Livermore, Calif.

Richard Doughton, Jr., has been released from active duty in the Office of Naval Material and has joined the staff of the Metallurgical Advisory Board, Washington, D. C.

Apex Smelting Co., Chicago, has made the following promotions and reassignments of its officers: **Robert K. Beck** will continue as vice-president and will assume the office of general manager of all operations; **Fritz Nussbaum**, vice-president, assumes the duties of manager of raw material purchases for all plants; **A. J. Peterson** has been promoted to the office of vice-president in charge of sales and advertising.

Alex L. Gresham has been appointed division metallurgist for standard practices in the metallurgical department of the American Steel & Wire Co., Cleveland.

Irvin R. Kramer, formerly in charge of metallurgical and ceramics programs in the Office of Naval Research, has joined Horizons Titanium Corp., Princeton, N. J., as assistant to the president in the Washington, D. C., office.

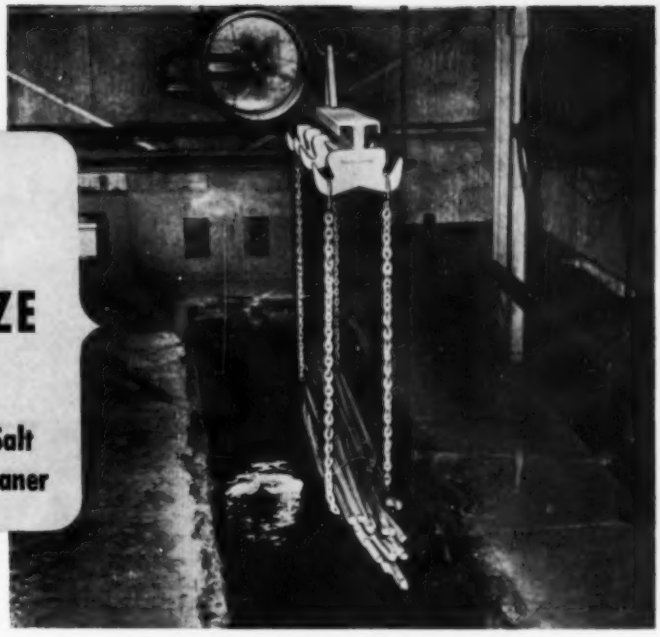
Marvin Beurkens, formerly associated with Nelson Metal Products, Inc., Grand Rapids, Mich., is now plant manager with the Acro Manufacturing Co., Grand Rapids.

R. D. Merrick, who graduated from Purdue University in June, has accepted a position as corrosion engineer with the Standard Oil Co. of New Jersey, Bayway, N. J.

Reidar Eriksen, formerly on the research staff of National Malleable & Steel Castings Co., Cleveland, has accepted a position as superintendent at Pearson Industrial Steel Treating Co., Chicago.

Felix Kremp has been granted leave by Crucible Steel Co. of America to act as chief of the Tool Steel Section, Iron and Steel Division, National Production Authority.

SMALL LOAD of bars ready for Virgo bath. Bars will then be quenched, dipped in dilute acid, and hosed clean. Total processing time: 11 minutes.



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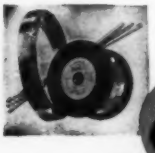
Modern pyrometers, within themselves, leave little to be desired as far as accuracy of temperature measurement is concerned. They're precision built instruments . . . delicately balanced . . . equipped with automatic cold-end compensators . . . designed and engineered throughout to give you the fine degree of accuracy you need. And, on 3 out of every 4 heat treating installations, these accurate meters are calibrated for CHROMEL-ALUMEL thermocouples . . . durable, dependable, sensitive couples unconditionally guaranteed to register true temperature—E.M.F. values within extremely close specified limits.

Yet, in spite of all the fine accuracy built into these meters and couples, uncontrollable "cold-end" errors will frequently occur when so-called "compensating" lead wires are used. Here's why . . .

As you know, when wires of different composition are joined together, they form a thermo-electric junction. In the case of "compensating" leads connected to your Chromel-Alumel couples, these junctions are located just outside the furnace and unprotected from heat. Now, as these terminals get hot . . . *and they often get very hot* . . . or when one junction gets hotter than the other, the opposing E.M.F.'s they generate tend to become more and more unequal. And this variable inequality is inevitably reflected by serious plus or minus errors registered by your meter.

How to eliminate this common cause of "cold-end" errors? Simple! Use CHROMEL-ALUMEL EXTENSION LEADS with your CHROMEL-ALUMEL thermocouples. For only by using these wires of identical composition can you be sure of getting the full benefits of accuracy offered by today's improved pyrometers. Our Catalog 59-R tells the complete technical story . . . want a copy?

CHROMEL-ALUMEL couples and leads are available through your instrument manufacturer or pyrometer service company . . . ask for them by name!



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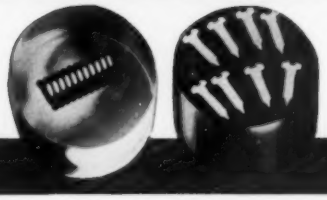
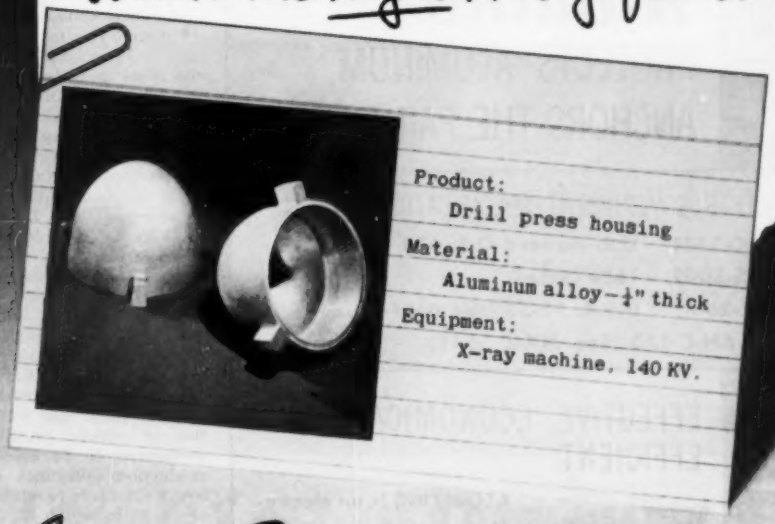


METALLURGICAL APPARATUS

What's the right X-Ray film?



ANSWER:

KODAK INDUSTRIAL X-RAY FILM, TYPE A

Hours of machining time were involved—so it was important that these housings be sound—that no irregularity should wait to be revealed by the cutting tools. In a matter of minutes, radiography checked for defects.

The radiographer chose Kodak Industrial X-ray Film, Type A, because this film has enough speed to keep exposures reasonably short even at low voltages. Its high contrast and fine graininess are also valuable in taking full advantage of higher kilovoltage machines in detecting irregularities in thick or dense materials.

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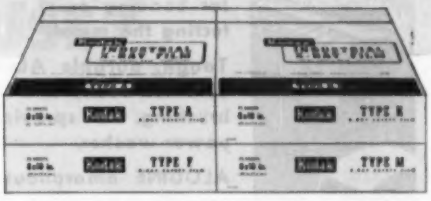

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To provide the recording medium best suited to any combination of radiographic factors, Kodak produces four types of industrial x-ray film. They also provide the means to check welds efficiently and thus extend the use of the welding process.

Type A—has high contrast with time-saving speed for study of light alloys at low voltage and for examining heavy parts at high kv. Used direct or with lead-foil screens.

Type M—provides maximum radiographic sensitivity for direct exposure or with lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltage and for much million-volt work.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays, exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.

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Wrought Al-Zn-Mg Alloys*

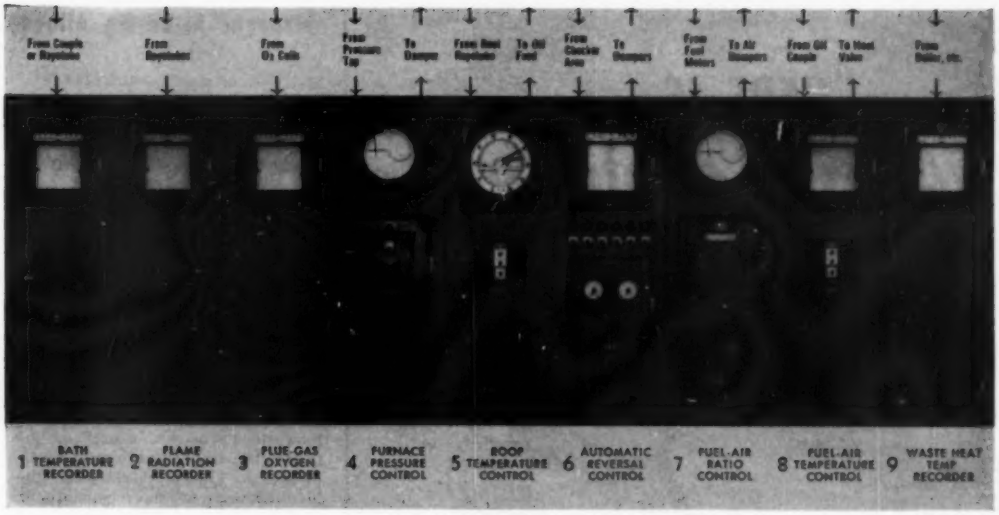
AVAILABLE LITERATURE on the aluminum-zinc-magnesium alloys is very weak on specific data regarding the effect of variations in composition upon mechanical and working properties, corrosion resistance, microstructure and age hardening characteristics. The present paper goes a long way in filling this gap. The range of composition investigated extends up to 12% Zn, 3.5% Mg, 3% Cu, 0.5% Cr, 0.8% Mn, 0.8% Fe and 0.8% Si; this is well beyond the present range of analyses for commercial alloys.

Since alloys of this type have been difficult to produce on a production scale, particular attention was given to solidification characteristics and microstructures. Long freezing range and a high proportion of eutectic constituents were considered to be associated with production difficulties and an attempt was made to establish a range of alloys in which the low-melting eutectic is present in only small amounts or entirely absent. This relation between amount of eutectic and production difficulties was found to hold true for two alloys of low eutectic content, made on a plant scale, when compared with an alloy of similar mechanical properties but containing substantially more eutectic.

A final correlation of results from all tests gave a range of compositions which combine high strength, a minimum of 10% elongation in 2 in., good corrosion resistance and a low proportion of eutectic constituents. The zinc content may be varied between 6 and 7% without appreciably affecting the optimum proportions of copper and magnesium, but the latter two must be varied in inverse proportion. The maximum amount of copper is 1.75% and the corresponding magnesium content 1.5%, if copper is absent magnesium may be increased to a maximum of 3%. Chromium additions for improving corrosion resistance should be limited to about 0.25% because of harmful effect on working properties. A small manganese addition of about 0.4% is beneficial, but iron and silicon are harmful. A small titanium addition of 0.05% is effective in refining the grain size.

(Continued on p. 116)

*Abstract of "Observations on Some Wrought Aluminum-Zinc-Magnesium Alloys", by M. Cook, R. Chadwick and N. B. Muir, *Journal*, Institute of Metals, Vol. 79, July 1951, p. 293-320.


1 BATH TEMPERATURE RECORDER
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3 FLUE-GAS OXYGEN RECORDER
4 FURNACE PRESSURE CONTROL
5 ROOF TEMPERATURE CONTROL
6 AUTOMATIC REVERSAL CONTROL
7 FUEL-AIR RATIO CONTROL
8 FUEL-AIR TEMPERATURE CONTROL
9 WASTE HEAT TEMP RECORDER

HOW MANY OF THESE 9 OPEN-HEARTH HELPERS CAN YOU USE?

THE open-hearth instruments shown above are used for four principal reasons . . . either to increase production, improve quality, save money, or give information which helps in planning future improvements.

1. Bath Temperature Recorder gives information which helps increase production and raise quality. Either thermocouple or Rayotube types available. Bath measurements are rapidly becoming standard practice in progressive mills and foundries.

2. Flame Radiation Recorder is a fuel engineer's research tool. Gives facts not otherwise available.

3. Oxygen Recorder saves fuel by showing combustion efficiency . . . regardless of stage of process or type of fuel. An "advanced" instrument well worth investigation by qualified engineers.

4. Furnace Pressure Control saves fuel by holding products of combustion in furnace for proper time and by helping smooth out the heating of checkers; lengthens refractory life by regulating air infiltration.

5. Roof Temperature Control speeds production by making it safe and easy to hold furnace continuously at maximum temperature; saves fuel and refractory, too.

6. Automatic Reversal Control often leads the parade for its combination of labor saving, checker saving, fuel saving, and general process improvement.

7. Fuel-air Ratio Control and related equipment is exactly what's needed for high-production heating speed and fuel efficiency when an open-hearth furnace burns a mixture of fuels, or switches fuels frequently.

8. Fuel Oil Temperature Control maintains correct viscosity of oil and therefore helps maintain even burner action and correct combustion.

9. Waste-heat Boiler-temp Recorder gives information for efficient combustion and proper boiler operation.

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Wrought Al-Zn-Mg Alloys

(Continued from p. 114)

These conclusions are based on a rather comprehensive investigation. Three series of alloys were prepared: 54 in 7-lb. ingots for mechanical and corrosion tests, 126 for the study of solidification characteristics, and the three production heats mentioned earlier. The results of most of the tests are given in graphic form in the original paper. Some 50 curves were plotted to show relations between composition and mechanical properties; over 30 others have to do with solidification and aging characteristics and with the correlation of all the data. A thorough study of macro and microstructures was made and the photomicrographs published may be helpful to anyone working on the identification of microconstituents in these complex alloys.

Heat treating characteristics were investigated separately for each alloy in the first series and it was found that most of the alloys developed the best combination of mechanical properties and corrosion resistance after a ½-hr. solution treatment at 860° F., quenching and then age hardening for 18 hr. at 260° F. More detailed studies were made of the aging characteristics of one of the alloys produced on a production basis and data are presented on the effect of time, temperature, and cold rolling after aging. Corrosion resistance was lowered by cold rolling after aging but a final heat treatment of 2 hr. at 257° F. was found to counteract this effect substantially.

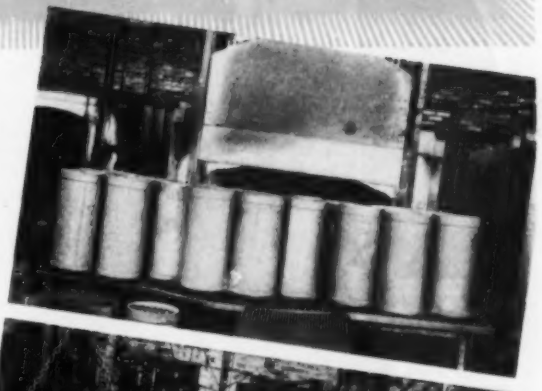
A 5-day immersion test in a standard 3% sodium chloride – 0.3% hydrogen peroxide solution caused considerable loss of strength in specimens aged at room temperature and at 195° F., but the corrosion diminished with increase in temperature of aging and loss of strength was slight for material treated in the range 250 to 270° F.

Microscopic examination of corroded specimens showed that temperature of aging affected the nature and degree of attack, intercrystalline penetration occurring in samples aged at 195 to 210° F., while only localized pitting attack occurred in material aged at 250° F. and above. Stress-corrosion data are promised in a subsequent paper. It should be pointed out that stress-corrosion characteristics have a very important bearing on the usefulness of these alloys and that they cannot be

(Continued on p. 118)

MANY VIP IN HEAT-TREAT FIELD HAVE USED PSC 'LIGHT-WEIGHT' EQUIPMENT FOR OVER 20 YEARS

Very Important People Are Perfection Tool and Metal Heat Treating Co. of Chicago, One of Largest Commercial Treaters in Nation. They Have Used PSC Containers Exclusively for Over 20 Years



Pictured at right are views in plant of Perfection Tool & Metal Heat Treating Co. of Chicago, showing PSC heat-treating containers in use. One of the foremost commercial heat-treaters in the country, Perfection has been employing PSC "Light-Weight" equipment exclusively since 1929, the year they placed their first order. Suggesting the many different types of containers and fixtures we supply Perfection, they use thirty different sizes of the carburizing boxes pictured at top.

Among the users of PSC heat-treating units are the majority of the metal-working firms in America today. Many of them have been users since the late 20's when this new light-weight, welded alloy equipment was introduced. PSC units furnished in any size, design or metal specification: annealing and carburizing boxes, fixtures, retorts, covers, etc. Send blue prints or write as to your needs.

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Heat-Treating Equipment for Any Product and Any Metal

Carburizing and Annealing Boxes
Baskets - Trays - Fixtures
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Hevi Duty Tool Room Combination installed in the plant of a large pump manufacturer.

for Precision Heat Treating of Tools and Dies

This Hevi Duty combination is a complete, low cost heat treating unit for tool rooms and small manufacturers. The "Temperite," air draw tempering furnace, "Treet-All," multipurpose furnace, and "Alloy 10," high temperature furnace, provide temperatures from 250° F to 2350° F. Prepared atmospheres are supplied by the "Atmo-Gen." Furnaces and the "Atmo-Gen" are available separately.

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DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS

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Wrought Al-Zn-Mg Alloys

(Continued from p. 116)

properly evaluated until this information is available.

One production heat falling within the composition range recommended by the authors had the following mechanical properties when tested in the form of ½-in. thick rolled sheet: yield strength (0.1%) 67,000 psi., tensile strength 83,000 psi. and elongation 16% in 2 in. Two similar alloys in the extruded form had yield strengths of 79,500 and 82,000 psi., tensile strengths of 89,000 and 92,500 psi., and elongations of 12 and 9.5%.

The principal commercial alloys of this type being produced in this country, Alcoa 75S, differs slightly in composition from the range recommended; the zinc content is about 1% lower and the magnesium plus copper about 1% higher. Reynolds R303 had the recommended zinc content and a magnesium plus copper range from 0 to 1.5% higher.

H. S. JERABEK

The Welding of Heat Resistant Alloy Sheets*

DEVELOPMENT of the gas turbine for aircraft has brought the problem of welding heat resistant alloys very much to the fore. The gas turbine, whether for jet or propeller propulsion, differs fundamentally from the normal reciprocating engine in that several main engine assemblies, such as the combustion and exhaust systems, are made almost throughout of sheet metal. These assemblies are made from heat resistant materials, since they operate at high temperatures, and both fusion and resistance welding are used to a remarkable extent in their construction.

In this paper, the welding techniques developed for the manufacture of this class of precision sheet metal work are discussed, together with some of the metallurgical and engineering factors involved. To exemplify some of the problems, a brief description of the sheet metal side of a representative gas turbine is given first, followed by some notes on the materials and the welding processes concerned.

(Continued on p. 120)

*Abstract of "Welding of Heat-Resistant Alloys in Sheet Form", by H. E. Lardge, Symposium on High Temperature Steels and Alloys for Gas Turbines, Iron and Steel Institute, February 1951, p. 217-224.

These steel "legs" for B-36 bombers, believed to be the largest die forgings ever produced in the 4300 series of nickel alloy steels are used in this giant landing gear by The Cleveland Pneumatic Tool Co., a leading producer of such equipment for commercial and military aircraft.

180-POUND INCONEL FURNACE FIXTURES CARRY 3500-POUND FORGINGS

What are believed to be the largest die forgings ever made of the 4300 series of nickel alloy steels are being used by Cleveland Pneumatic Tool Company, Cleveland, Ohio, in the landing gear of the Air Force's immense B-36 heavy bomber.

Since they weigh from 1500 to 3500 pounds each, handling these forgings during heat treatment posed a tough problem.

The treatment necessary was: 8 hours at a maximum of 1700°F. and air cooling; 8 hours at a maximum of 1500-1600°F. and oil quenching; and finally, tempering at 1000°F.

A suspension fixture was wanted that could carry the forging through the entire normalize-quench-temper cycle. But it had to be absolutely dependable. If it should fail in the furnace, dropping 3500 pounds of dead weight to the furnace floor, either the forging or the furnace or both could suffer extensive damage. At the very least, the job of removing 3500 pounds of red-hot metal would be tough.

Cleveland Pneumatic recalled their past experience with Inconel® furnace equipment. Then they made a study of Inconel's high-temperature characteristics, noting particularly such properties as its 1000-hour stress-to-rupture strength at 1600°F. of 2700 psi. It looked as though Inconel would do the trick, if the proper design could be worked out.

Their engineers designed a fixture that seemed practical, and they asked Ohio Iron Works Company of Cleveland to fabricate three fixtures from the design. These were made from 3 and 4-inch diameter Inconel rod and 1-inch Inconel plate. One-inch holes were drilled in the rods, to lighten the fixtures.

When completed, each Inconel fixture weighed 180 pounds – slightly more than 1/20th the weight of the forgings they carry.

They have been in steady use for 17 months now, and still show no sign of wear.

The reasons why Inconel gives such excellent service are not hard to find. Its rugged strength at red heat, coupled with strong resistance to sulfur-free furnace atmospheres, make Inconel one of the real high-temperature "workhorses" in use today.

Right now you may find Inconel hard to get because so much is being diverted to defense needs. But if you have a high temperature metal problem INCO's High Temperature Engineers will gladly help you search out a solution. Ask them to send you a High Temperature Work Sheet where you can outline your problem.

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OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE. ROUNDS, SQUARES, FLATS, HEXAGONS, OCTAGONS

BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS.

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BEST USE OF AVAILABLE STEEL

In times of emergency, substitutes can often be used to good advantage.

Right now, the urgent requirements of production for national defense are taking the lion's share of high-grade alloying materials.

That is as it should be, of course. But the fact remains that many manufacturers are being confronted daily with knotty problems of production.

Frequently these difficulties can be solved by using substitute grades or alternate methods of manufacture and treatment.

To help you decide *which* substitute grades you can use and *how* you can use them most effectively, call on our staff of metallurgical experts.

A letter – or a phone call – will focus Wheelock, Lovejoy's specialized technical skill and long experience on your individual problems.

And we'll be delighted to be of service.

Write today for your FREE COPY of the Wheelock, Lovejoy Data Book, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.

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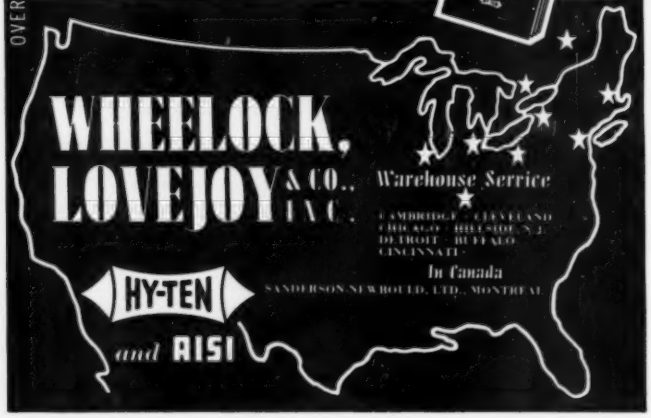


The Welding of Heat Resistant Alloy Sheets

(Continued from p. 118)

MATERIALS

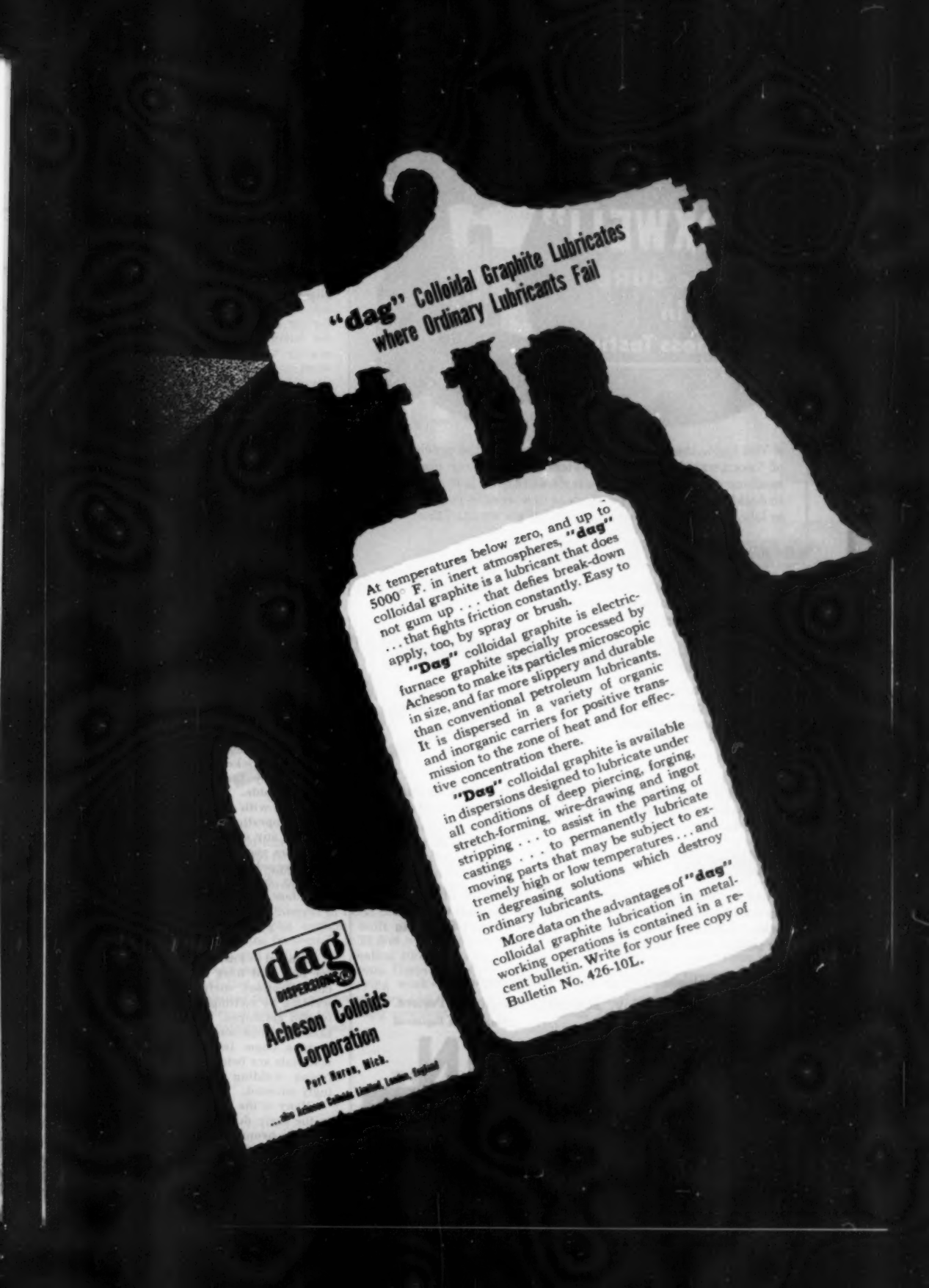
In the materials under consideration, the properties needed for successful high-temperature operation, namely, good mechanical strength and resistance to oxidation and corrosion, result from the presence of nickel and chromium in varying amounts. The alloys depend on a thin but highly adherent complex oxide film to withstand further oxidation and attack at temperature. The oxide films produced by heat treatment of the parts during manufacture can be very troublesome in welding (particularly resistance welding), and must be removed by pickling or other means. The annealing process for these alloys is a simple one, consisting of heating to 1050° C. (1920° F.) and cooling in still air or in a controlled atmosphere. The removal of some of the oxides so produced, however, is not quite so easy.

The main factors affecting fusion welding are the relatively high rates of thermal expansion and the low heat conduction, as compared with mild steel. The main factors affecting resistance welding technique are the high electrical resistance and low thermal conductivities, which allow the alloys to be welded with less electrical energy than is required for mild steel. The materials, being tough, require higher mechanical pressure at the welding electrodes than does mild steel, and these higher pressures also help to consolidate the weld nugget.

Mild steel, although hardly a heat resistant material, is used for air casings and other components where the operating temperature does not exceed 300° C. (570° F.). Flanges are made from mild steel plate, flame-cut and machined before being spot or seam welded to the drawn casings. One advantage in including mild steel in the list of materials is that it forms a basis for comparison with the other materials. Its fatigue value is not high, but it possesses good damping capacity — an excellent characteristic when high-frequency pressure fluctuations are present.

Austenitic stainless (D.T.D. 171) of the stabilized 18-8 variety is used extensively for exhaust-unit and jet-pipe constructions where tempera-

(Continued on p. 122)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The Welding of Heat Resistant Alloy Sheets

(Continued from p. 120)

tures are of the order of 600 to 650° C. (1110 to 1200° F.). Although the fatigue strength and notch sensitivity are good, the rather low damping capacity of this steel led to extensive fatigue failures along the edges of the welds, and for this reason, it was replaced by mild steel for air casings and by Nimonic 75 for fairing skins. The 18-8 steel is readily weldable by all the processes concerned and has excellent deep drawing properties.

As mentioned previously, machined flanges of comparatively heavy section are employed in the construction of these engines and are usually made from centrifugally spun cylinders of a tungsten-bearing, austenitic steel of 24-12-3 chromium-nickel-tungsten composition. Wherever possible, it is customary to weld the flanges to their adjacent sheet metal parts, allowing distortion and shrinkage to take place before finally machining the flanges to give the assembly the dimensional accuracy required.

For flame tube construction, where temperature and thermal stresses are high, Inconel was previously used, but with the introduction of Nimonic 75, the latter material was immediately adopted. Nimonic 75 was developed for operation at temperatures up to 750° C. (although in practice this has often been exceeded locally) and is an 80-20 nickel-chromium alloy stiffened by the presence of titanium carbide. It is a very tough material, with good creep and fatigue properties; it can be formed cold by any of the normal forming processes such as rolling, pressing, and deep-drawing, and it work-hardens rapidly and requires full interstage annealing.

FUSION WELDING

General — Fusion welding is used for butt and fillet welds as design considerations dictate; some edge welding by melting adjoining edges is also employed. As the gas turbine develops and more powerful designs come into being, thicker materials are being introduced, and fusion welding is being increasingly adopted.

Many of the failures experienced in the early development phases of the jet propulsion engine were

(Continued on p. 124)

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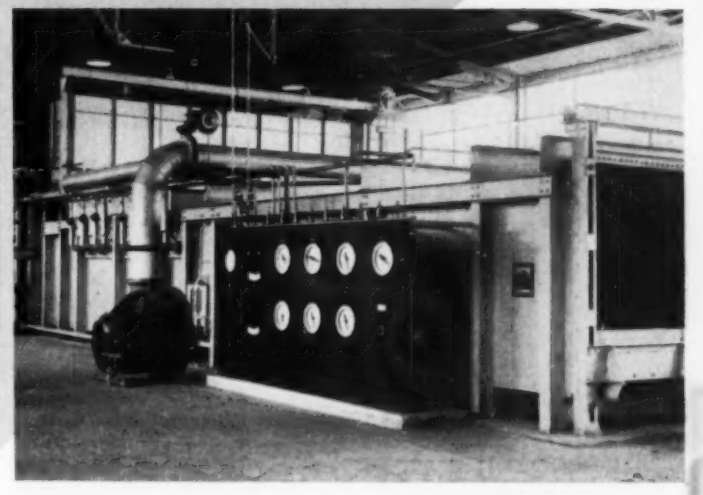

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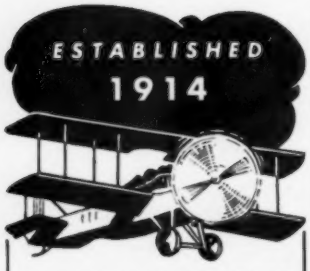

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The Welding of Heat Resistant Alloy Sheets

(Continued from p. 122)

caused by fatigue at the welds. Under conditions of dynamic loading, fusion welds are subject to concentrations of stress for the following reasons:

1. Change of section at the edge of the weld.
2. Different metallurgical structure of the wrought sheet and the cast weld metal.
3. Changes of section caused by surface irregularities, internal porosity, or inclusions.
4. Combinations of any or all of the foregoing, coupled with static, thermal, and internal stresses.

Although thermal stressing can be kept within bounds by good design, and internal stresses can be reduced by an intelligent sequence of welding and a judicious use of stress relieving, not much can be done with the other factors except to see that the actual welding is of the highest quality. It is, therefore, agreeable to recall that the failures directly attributable to faulty welding have been extremely few. (Abstractor's note: No mention is made in this article of weld cracking which is often encountered in fabricating these materials.)

Oxy-Acetylene Torch — All the alloys can be welded by this well-tried process, which has been used on this class of work to cover thicknesses from 0.0164 to 0.25 in. On the heavier gages of Nimonic 75 (over 0.125 in. thick) oxy-acetylene has been found to give more porosity-free welds than any other fusion process, but the reasons for this are not fully understood.

Carbon Arc — This process, or more specifically the carbo-flux process, was preferred to oxy-acetylene for the thinner gages because of the lower distortion value; it has been used for butt welds on thicknesses ranging from 0.0164 to 0.080 in., although for fillet welds thicker gages have been welded when required. Previously, it was used for the welding of the discharge nozzle components and for assembly — to keep distortion within reasonable bounds — but it is being replaced in many instances by the argon-arc process. Nimonic 75 is readily weldable by the process, but to reduce oxide inclusions, the material must be really clean and should be pickled prior to welding. Satisfactory welds have

(Continued on p. 126)

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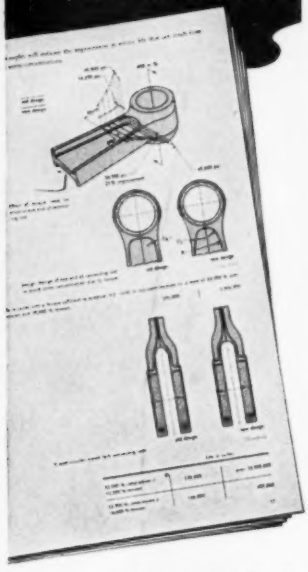

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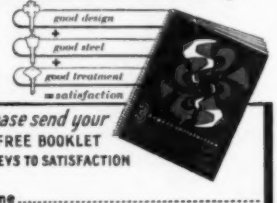

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The Welding of Heat Resistant Alloy Sheets

(Continued from p. 124)

been obtained between Nimonic 75 and each of the austenitic steels employed.

Argon Arc—The argon arc is a comparatively new process as applied to alloy steels and is, in general, applicable to those welds normally produced by the carbon arc, which it is largely superseding. The electrode is of tungsten, and chemical fluxes are not required as the arc is surrounded by an envelope of the inert gas argon.

The process has been applied manually to 18-8 stainless steel up to $\frac{1}{8}$ in. thick, for butt and fillet welds, and it is essential that the tungsten electrode should not touch the work otherwise contamination of the weld metal takes place. Nimonic 75 also appears to be sensitive to tungsten contamination, but it is interesting to note that Nimonic 75 has been welded to H. R. Crown Max—an austenitic steel containing tungsten—merely by melting the Crown Max with the arc.

Metallic Arc—Until recently, this process has not found many applications in this class of work, but as the general trend of engine development is to use thicker materials, the metallic-arc process is now being increasingly employed. The minimum thickness considered suitable for the process is 0.064 in. The metallic-arc process is measurably faster than the other fusion processes, and when properly applied, the distortion produced is not unreasonable.

RESISTANCE WELDING

From the resistance welding aspect, the most important properties are the high electrical resistivities and low thermal conductivities, which allow the alloys to be welded with less electrical energy than is required for mild steel. The high resistances give a greater heating effect for a given current, and the low thermal conductivities allow the heat thus generated to be retained more readily in the weld zone. This tendency to retain heat can influence the amount of distortion; however, advantage is taken of the corrosion resistance of the alloys, and distortion is kept down by welding under water. The rapid cooling obtained by welding under water prevents the formation of

(Continued on p. 128)

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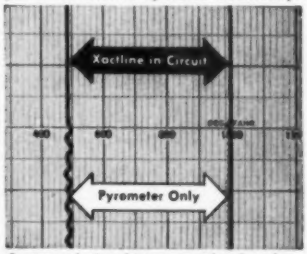

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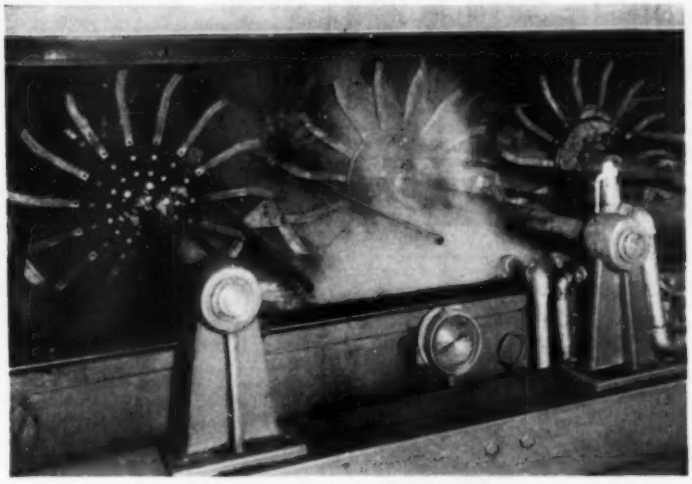

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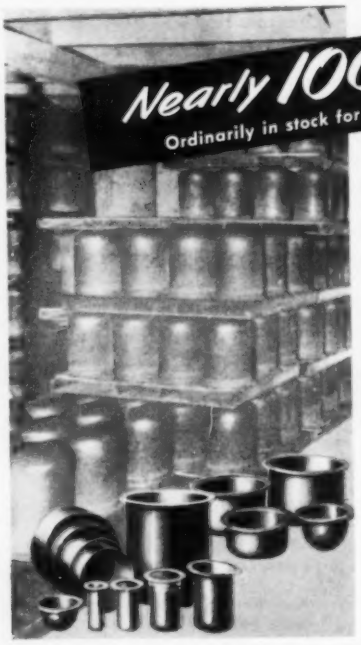

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The Welding of Heat Resistant Alloy Sheets

(Continued from p. 126)

undesirable carbides in the heat affected zone. The electrode pressure required for the heat resistant alloys are generally much higher than those for mild steel.

Spot Welding — Spot welding is used for "tacking" prior to stitch or seam welding, and also for structural purposes. Fine gradation of the welding current is most desirable, and may be obtained by closely stepped transformer tappings or, preferably, by the use of "phase-shift" heat control.

It is often necessary to weld different materials of similar thicknesses which is done by having an electrode tip of high conductivity against the material with the lowest heat conductivity, and a tip of low-conductivity alloy against the material with good heat conductivity.

Stitch Welding — This process is employed for giving a continuous joint by means of a series of overlapping spot welds on irregularly shaped components, or where for some reason roller seam welding cannot be used. Welding speeds of 80 to 140 welds per min. are usual in this work.

Seam Welding — The adoption of this process for gas turbine work opened the way for high production rates in the construction of combustion and other sheet metal parts.

Effective cooling is most important for seam welding, as the energy required to make a given joint is put into the work in a fraction of the time required for stitch welding, and distortion can be most serious, sometimes producing extensive shrinkage cracks on cooling. Welding under water jets has proved satisfactory in this respect, although a much greater flow of water is required than for stitch welding. As with spot welding, the electrode pressures required for seam welding the high-temperature alloys are generally much higher than the pressures required for mild steel.

Seam welding machines can also be used for roller spot welding by modifying the timing so that the intervals between the welds are long enough to give the requisite spacing. This method has been found most effective for welding strengthening bands to cylinders where a continuous joint is not required.

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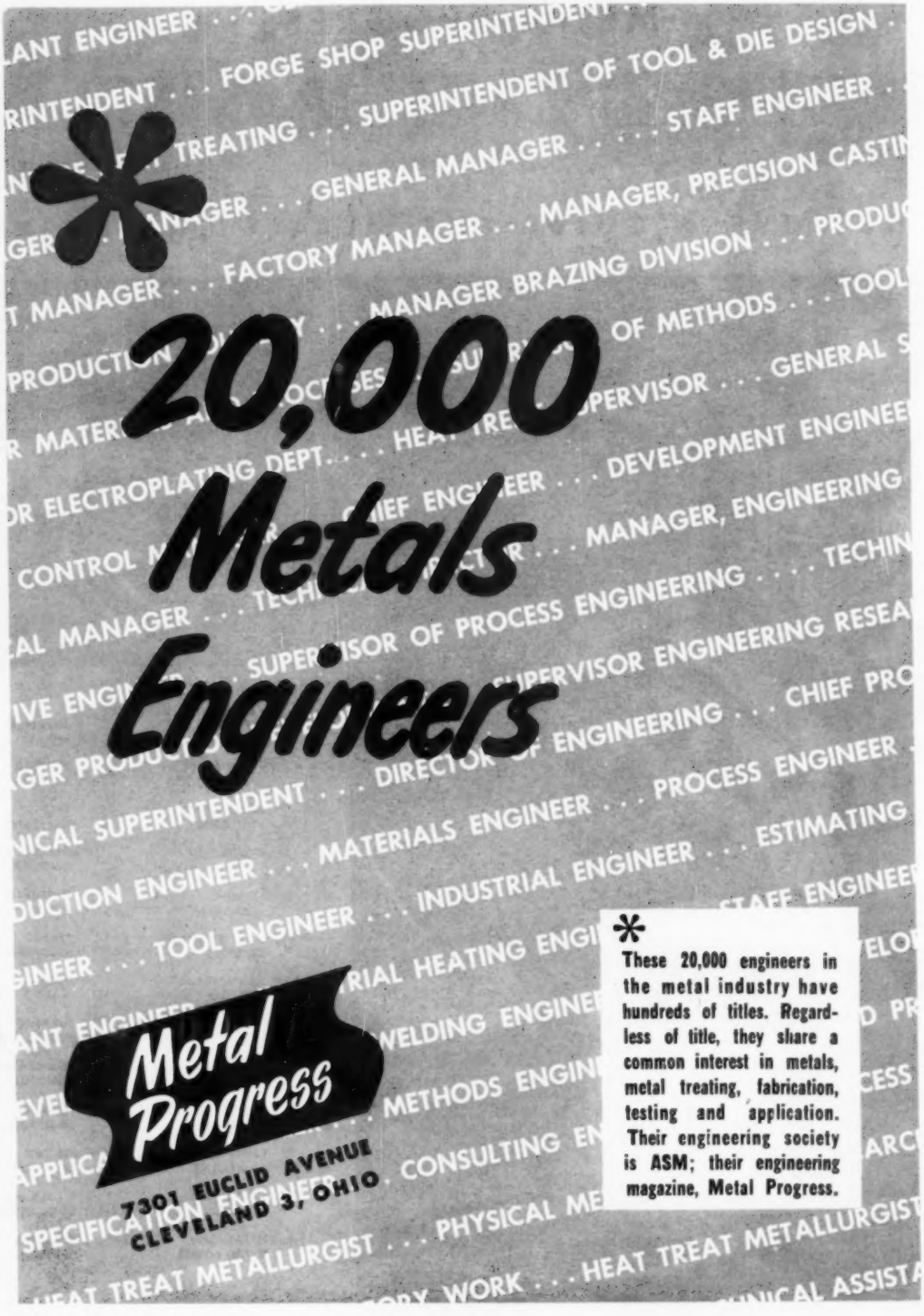
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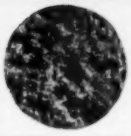	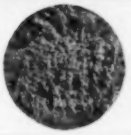

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MORE IRON AND STEEL SCRAP . . . OF ALL KINDS!

Steel mills and foundries need more scrap—all sorts of *idle* iron—from all types of plants.

Search *your* plant for this idle metal . . . work with your local scrap dealer to increase supplies of badly-needed iron and steel scrap.

The Structure of Cast Iron

By Alfred Boyles
U. S. Pipe & Foundry Co.

A book that tells what cast iron really is and gives the facts basic to an understanding of applications.

154 pages . . 94 illus. . . $3.50

American Society for Metals
7301 Euclid Cleveland

IMPOSSIBLE?

NOW POSSIBLE

95-LB. PRECISION

CASTINGS

Hastelloy, 316, 347, 410, 431 s.s. 4130, 4120, 1020, Copper, Aluminum

AN EXPERIENCED ENGINEERING STAFF AVAILABLE TO HELP WITH YOUR DESIGN PROBLEMS

INQUIRIES INVITED . . .
BROCHURE ON REQUEST

ALLOY PRECISION CASTING CO.
E. 45 ST. & HAMILTON • CLEVELAND, O.

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RHODIUM Plating

In these days of restrictions on the use of the usual plating metals, the precious metal, rhodium, becomes important as a replacement for them, especially for small articles and parts.

Rhodium is hard and brilliantly white and it cannot tarnish. No acid nor mixture of acids attack it. Our solution has excellent throwing power.

Suggested objects for plating with rhodium are optical mounts, contacts for communication equipment, radar components, surgical instruments and pen and pencil sets. The practical plater's own experience will suggest many others to him.

Commercial rhodium plating was developed in our laboratories. Baker Rhodium Plating Solution is the original and is made under the direction of the men who developed the process.

● Let us send you *Directions for Rhodium Plating.*

Baker & Co., Inc.

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DIPPING BASKET

Highest quality baskets ...strong, safe to handle. Mesh can be replaced when worn. Long life. Standardized for fabrication to any size. Send specifications to Dept. B.

(See our ad on Heat Treating Equipment in this publication.)

ROLOCK INC.
FAIRFIELD, CONN.

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Model JC-25

Helps 1 man do the work of 5

All-electric steam-detergent cleaning. For plant maintenance and industrial housekeeping. Pressures to 200 p.s.i. Other sizes available. *Write for bulletin 74-15.*

Livingstone Engineering Company
Manufacturers of Steam Generato
100 Grove Street • Worcester 5, Mass.

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SCRAPPY SAYS:
AID DEFENSE
MORE SCRAP TODAY...
MORE STEEL TOMORROW

Nonferrous Scrap Is Needed Too

CLEANING EQUIPMENT and MATERIALS

DEGREASERS
•
METAL PARTS WASHERS
•
DEGREASING SOLVENTS
TRICHLORETHYLENE
PERCHLORETHYLENE
•
EMULSION and ALKALINE CLEANERS
•
RUST-PROOFING and PAINT-BONDING COMPOUNDS

DETREX CORPORATION

LIST NO. 11 ON INFO-COUPON PAGE 143

Surface Treatment of Metals

A Symposium by 15 Authors

Includes chapters on anodic treatment of aluminum, passivation and coloring of stainless steel, surface treatment of magnesium, zinc and tin coatings, diffusion coatings, and various mechanical surface treatments.

400 pages . . 140 illus. . . $5.00

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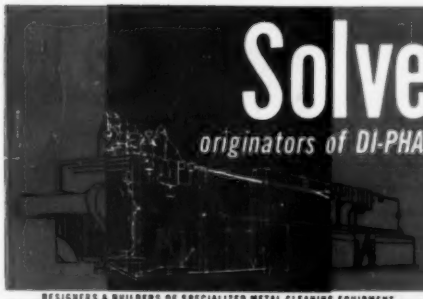
originators of DI-PHASE metal cleaning



DESIGNERS & BUILDERS OF SPECIALIZED METAL CLEANING EQUIPMENT

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Manufactured to exacting specifications for:

- ANODIZING
- PLATING
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and Conveyor Purposes.

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4632 West 21st Place CICERO, ILL.

NATIONAL RACK CO., INC.
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IMPERIAL PLATING RACK CO.
1613 Industrial Avenue FLINT, MICH.

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SEAL-PEEL COATINGS

PROTECT METALS AGAINST

RUST
CORROSION
SCRATCHES
ABRASION

Extensive laboratory facilities are at your service for any rust, waterproofing, or corrosion-resistant problem.

Seal-Peel, inc.
11400 E. 9 MILE ROAD
VAN DYKE (DETROIT), MICH.

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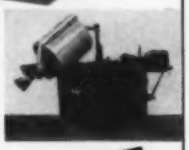
For economical bulk plating with fast loading and unloading features investigate the Daniels DLS Plating Barrels. Write for illustrated catalog today.



Now available, a new H series of Daniels Plating Barrels for low cost plating of small parts. Write for illustrated catalog today.

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MANUFACTURERS and DISTRIBUTORS
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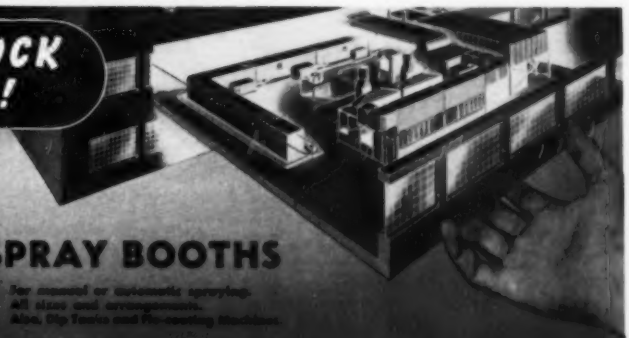

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Batch—Conveyorized.
Oil—Gas—Steam—Electric Heated.

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Straight Line—Rotary—U-shaped.
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SPRAY BOOTHS

For manual or automatic spraying.
All sizes and arrangements.
Also, Dip Tanks and Pre-treating Machines.

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Megacycle Tube Type Machines

Soldering • Brazing • Bombarding
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Sizes: Standard—2,4,10,25 KVA; Custom—to 100 KVA

Fast • Powerful • Reliable

Challenge Comparison—Value • Quality • Price • Design • Appearance

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Complete data, application photos, prices, delivery in New illustrated Catalog. Write on your company letterhead.

Since 1930... Pioneers in Megacycle Heating

SHERMAN *Industrial Electronics Company*

New York Area Office and Plant
505 Washington Ave., Belleville 9, N. J.

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HEAT TREATING FURNACES

for Every Heat Treating Process

★

CONTROLLED ATMOSPHERES

★

DIRECT FIRED

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CIRC-AIR DRAW FURNACES

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Specially Engineered for Your Particular Needs

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GAS • OIL • ELECTRIC

INDUSTRIAL HEATING EQUIPMENT

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THE MOST ADVANCED SALT BATH FURNACES FOR . . . .

Batch Type Work	*Conveyorized Type Work*

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Phone, Diamond 1-2520

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ALWAYS SPECIFY THE BEST

Morrison

ENGINEERED

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ANNEALING	CORE BAKING
HARDENING	PAINT BAKING
TEMPERING	ROD BAKING
GALVANIZING	MOLD DRYING
NORMALIZING	LITHOGRAPHING
HEAT TREATING	ANNEALING
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Morrison ENGINEERING CORP
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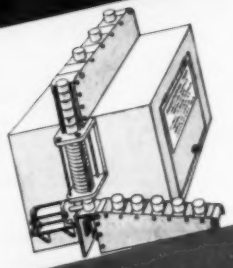
Low Frequency (60-cycle) Induction Heating



the production advantage you have been seeking

• Practically every extrusion press in the last three years has been equipped with a Magnethermic 60-cycle billet heater. Now, Magnethermic furnaces have been adapted for brass, copper, magnesium and steel for annealing, forging, extrusion and other primary and secondary heating, both ferrous and non-ferrous.

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- SIZES UP TO 20,000 LBS.
- EASY INSTALLATION—CONNECT POWER LEADS AND COOLING WATER, THAT'S ALL

Prompt Answer to Your Inquiry

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60-CYCLE
MAGNETHERMIC
corporation
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INDUCTION HEATING

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Whenever you have a heating problem that involves heat resistant parts, take advantage of Standard's long experience in producing alloy castings engineered to your specific need. Conveyors, roller hearths, trays, containers, fixtures radiant tube assemblies—and many more designs for a wide variety of applications are available.

* Consult the engineering representative nearest you—or write for the interesting 4-page Bulletin No. 1.

STANDARD ALLOY CO., INC.
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PERECO ELECTRIC FURNACES AND KILNS

PERENY EQUIPMENT COLUMBUS O.

Clean heat, accurately controlled. Wide choice of models for research, pilot plant, and production. Standard units for temperatures from 450° to 3000° F., or special research equipment up to 5000° F., to meet *your* needs.

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EXPORT DEPT. The Inland Export Co., Inc. Greer Bldg., New Castle, Pa., U.S.A.

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Non-Case

Anti-Carburizing Paint

Applied to any part of steel prior to carburizing, Non-Case protects that specific part from the absorption of carbon. Here is an invaluable coating that prevents carburization, or hardening, of certain spots or sections of steel parts. Easy to use, Non-Case is available in *quart or gallon cans.*

Write for Descriptive Literature

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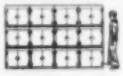
PORTABLE ELECTRIC OVENS

FOR THE METAL WORKING INDUSTRY

Standard Models for Every Special Need

LOW COST



Model HT-2
Max. Temperature 1000° F.
Approx. 4 cu.ft. working space.

220 Volt — 1 phase. Thermostat controlled. Can be used in groups or banks.

Standard models 225° F and up.

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Trouble-Free

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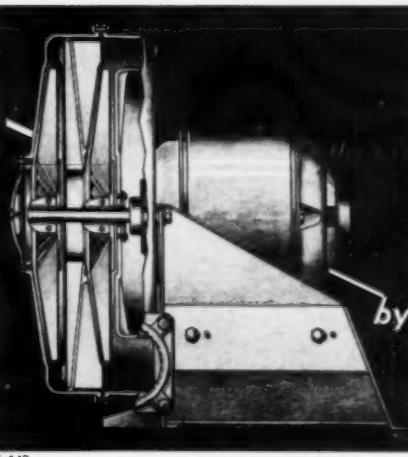

by North American Manufacturing Company
GAS OR OIL COMBUSTION EQUIPMENT
CLEVELAND 5, OHIO

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FOR ALLOY CONSERVATION

USE

KASENIT

SURFACE HARDENING COMPOUNDS

- NON POISONOUS
- NON EXPLOSIVE
- NON INFLAMMABLE

★Kasenit saves you money by simply and inexpensively providing controlled surface hardness on plain alloy and carbon steel parts. No scaling or warping. Try KASENIT now.

1-lb. Trial Size..... $2.00

KASENIT COMPANY
799 Greenwich St., DEPT. MP
New York 14, N. Y.
Established 1912

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INSTRUMENTS AND CONTROL FOR HEAT TREATING FURNACES

A complete summary of Hays products applicable to processes such as annealing, brazing and calorizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages, and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO_2 recorders are covered.

Send for Bulletin 49-750

THE HAYS CORPORATION
MICHIGAN CITY 26, INDIANA

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Control Temperatures More Closely

REDUCE COST • SAVE TIME

This Catalog of Improved Pyrometer Supplies shows you how!

Get your FREE Copy Today!

★ Thermocouples ★ Protection Tubes
★ Thermocouple Wire ★ Lead Wire
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ARKLAY S. RICHARDS CO., Inc.
NEWTON HIGHLANDS 61, MASS.

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Serving the
HEAT TREATING INDUSTRY
Since 1930

- Complete Service on Control Equipment
- Thermocouples
- Protection Tubes
- Charts and Lead Wire

THE CLEVELAND ELECTRIC LABORATORIES COMPANY

1988 E. 66 St.

Cleveland 3, Ohio

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FREE
The Quenzine Story

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . . .

Aldridge Industrial Oils, Inc.
3401 W. 140th St., Cleveland 11, Ohio

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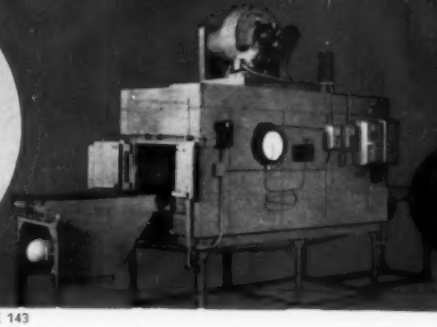
COMPLETELY AUTOMATIC HEAT TREATING OVENS AND FURNACES

Typical of many automatic and time-operated heating ovens and furnaces designed by Carl-Mayer, the pictured illustration conserves valuable man-hours. Conveyor and batch-type furnaces up to 2000° F., using gas, oil, or power, can be designed and built to meet your heating and processing problems.



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CLEVELAND, OHIO

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Diversified Heat Treating Facilities for . . .

STEEL • ALUMINUM • MAGNESIUM

FORGINGS · CASTINGS · TOOLS AND PARTS

Carbonitriding
Controlled Atmosphere
Cyanide and Neutral Baths
Liquid, Gas and Pack Carburizing
Induction Heating

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Pit Type Convection Furnaces
Large Car Bottom Furnaces
Production Box Furnaces

Solution Heat Treatment
Hardening
Tempering
Normalizing
Annealing

•

Grit Blasting
Shot Blasting
Shot Peening

Our management, production and sales staff are all metallurgically trained. Their combined experience is available for complete heat treating counsel without obligation.

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Send for Free Booklet of Complete Facilities

Pearson INDUSTRIAL STEEL TREATING CO.

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42ND YEAR

A VINCENT PROCESS

For

EVERY HEAT TREATING NEED

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300-TON DAILY CAPACITY

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MODERN FACILITIES

VINCENT STEEL PROCESS CO.

2434 Bellevue Ave. • Detroit 7, Mich.

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HEAT TREAT at it's Best!

COMPLETE SERVICE including —

BRIGHT HARDENING OF STAINLESS STEELS...STEAM TREATING HIGH-SPEED CUTTING TOOLS ... HARDENING ... TEMPERING ... CLEANING.

Our Metallurgical Engineers can help with your metal treating problems.

COMMERCIAL STEEL TREATING CORP.

6100 Tireman Detroit 4, Mich.
TYler 6-6086

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YOUR COMMERCIAL **HEAT TREATER** IN DETROIT

OFFERS FACILITIES FOR:

1. **ALUMINUM** - CAP. 500,000/ PER MO.
2. **MINUTE PARTS** TO 2-TON DIES
3. **BRIGHT HARDENING** OF STAINLESS STEEL

ALL TYPES OF HEAT TREATING CAN BE DONE BY . . .

STANDARD STEEL TREATING CO.

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HEAT TREATING

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St. Louis 15, Missouri

Lindberg Steel Treating Company is ideally equipped to serve you in any phase of the heat treating field.

- Located in four major industrial areas.
- Equipped to perform every process — from the most conventional to the latest and most difficult techniques.
- More than 25 years of experience in processing almost every conceivable type of metal part.
- Trained and experienced metallurgical engineers available for consultation at any time — just call or write.

Write or call for your copy of the illustrated booklet "Surface Hardening of Stainless Steel."

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LINDBERG STEEL TREATING CO.

222 N. Laflin Street Chicago 12, Illinois Phone MOnroe 6-3308

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Heat Treating Services

STEEL TREATING

• FLAME HARDENING
• CARBURIZING & HARDENING
LIQUID • PACK • GAS
• SHOT BLASTING • ANNEALING
• TENSILE TESTING • NORMALIZING

HEAT TREATING & STRAIGHTENING OF BARS UP TO 22' LENGTHS

MEMBER AMERICAN SOCIETY FOR METALS

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THE W. S. BIDLE CO.

1409 EAST 40TH ST. • CLEVELAND, O.

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DON'T WAIT... COOPERATE!

The U.S. Needs Your Steel Scrap, Now

Nonferrous Scrap Is Needed Too

BRIGHT HARDENING and ANNEALING of STAINLESS STEEL
HEAT TREATMENT of ELECTRICAL ALLOYS
ATMOSPHERE CONTROLLED HEAT TREATING
and STANDARD OPERATIONS

DREVER CO.
HEAT TREATING DIVISION

224 CAMBRIA ST. PHILADELPHIA 33, PA.

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Heat Treating OF METALS

Flame Hardening			Stress Relieving
Induction Hardening	*		Normalizing
Chapmanizing		*	Gas, Pack or Liquid Carburizing
Nitriding			Annealing
Cyaniding	*		Silver-Finish Hardening of Dies or Tools
Cadmium, Tin or Copper Plating	*		Roto-Blasting
Anodizing or Alrocking of Aluminum			Silver or Copper Brazing

PITTSBURGH COMMERCIAL HEAT TREATING CO.
90 49th Street Pittsburgh, Pa.

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Boron Steel

Just off the press . . . . a timely collection of eight articles on boron steel, reprinted from METAL PROGRESS.

Write now for your copy of this new publication. Price is $1.00.

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American Society for Metals

7301 Euclid Cleveland

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Scientific STEEL IMPROVEMENT

BIG AS THEY COME
OR BY THE HANDFUL

Our Services: Electronic Induction Hardening, Flame Hardening, Heat Treating, Bar Stock Treating and Straightening (mill lengths and sizes), Annealing, Stress Relieving, Normalizing, Pack, Gas, or Liquid Carburizing, Nitriding, Speed Nitriding, Aerocasing, Chapmanizing, Cyaniding, Dry Cyaniding, Sand Blasting, Tensile and Bend Tests.

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COMPLETE
METALS TESTING
SERVICE
• CHEMICAL
• PHYSICAL
• SPECTROGRAPHIC
• RADIOGRAPHIC
• METALLOGRAPHIC
★ SPECIAL STUDIES WITH RADIOACTIVE TRACERS
• UNITED STATES TESTING COMPANY, INC.
ESTABLISHED 1880
1530 PARK AVENUE HOBOKEN, N. J.
NEW YORK • BOSTON • PHILADELPHIA • MEMPHIS • DALLAS
HOBOKEN • PROVIDENCE • CHICAGO • LOS ANGELES • DENVER
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Solve
INSPECTION
DEMAGNETIZING
SORTING
PROBLEMS with
MAGNETIC ANALYSIS EQUIPMENT
Electronic Equipment for non-destructive production inspection of steel bars and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.
This Equipment is now employed by more than 40 Steel Mills and many Steel Fabricators.
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Electrical Equipment for efficient production demagnetizing of steel bars and tubing. When used with Magnetic Analysis Equipment inspection and demagnetizing can be done in a single operation.
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Electronic Instruments for production sorting of ferrous and non-ferrous materials and parts for variations in composition and physical properties.
ALSO MAGNETISM DETECTORS
Inexpensive pocket meters for indicating magnetism in ferrous materials and parts.
For information write "THE TEST TELLS"
MAGNETIC ANALYSIS CORP.
42-44 Twelfth St. Long Island City 1, N. Y.
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MERIAM
MANOMETERS
U-TYPE • WELL TYPE • DUAL TUBE
FLOW METERS
DRAFT GAUGES
For measuring pressure, vacuum and differential pressure of liquids and gases. Also a complete line of accessories.
ASK FOR CATALOG C-12
THE MERIAM INSTRUMENT CO.
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U-TYPE MANOMETER
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Headquarters for
NON-DESTRUCTIVE TESTING
and
MEASURING INSTRUMENTS
★ ★ ★
ULTRASONIC & MAGNETIC
INSPECTION EQUIPMENT
Crack & Defect Locators
Metal Sorters
Ultrasonic Thickness Gages
ELECTRONIC MICROMETERS
For production measurement of precision components to within 0.000020 in.
J. W. DICE CO.
ENGLEWOOD, N. J.
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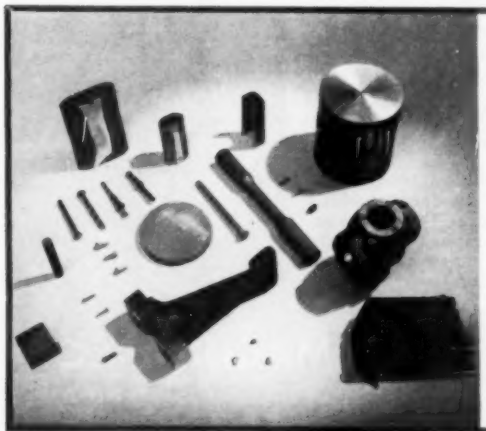

IF CONTROL OF THESE PARTS
IS YOUR PROBLEM . . .
SPECTROSCOPY IS THE
ANSWER!
Undivided responsibility for complete installation of all Spectrographic equipment.
NATIONAL SPECTROGRAPHIC
LABORATORIES, INC.
6300 EUCLID AVENUE CLEVELAND 3, OHIO
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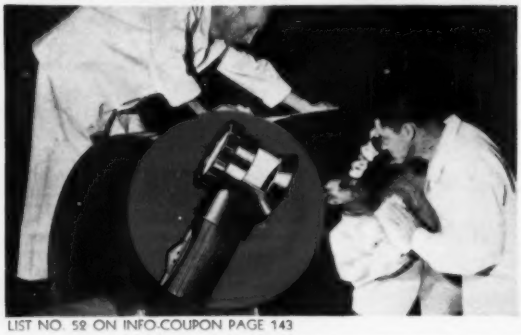
FLASH-O-LENS Lights and Magnifies

METAL SURFACES FOR FAST, ACCURATE INSPECTION



Another FLASH-O-LENS at work—this time at Eastman Kodak Company!

You *too* can cut down inspection time and improve product quality by using this simple, handy, low-cost instrument that *spotlights* the work and *magnifies* it at the same time . . . the FLASH-O-LENS!

Just put a FLASH-O-LENS on the part you're inspecting. Built-in bulb puts light *on* the field of vision—keeps it *out* of user's eyes. Accurately ground lenses give sharply detailed enlargement. Result: time-and-eye-saving inspection, surer maintenance of quality standards.

Battery-operated and plug-in models—$10.65 up. Write for literature on suggested applications, types and prices.

E.W. PIKE & COMPANY
492 NORTH AVE. ELIZABETH, N. J.

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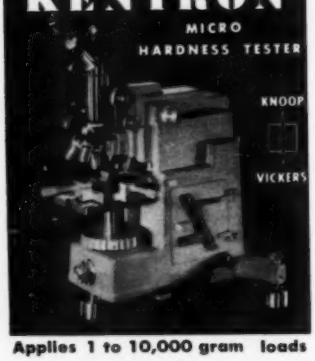
KENTRON

MICRO HARDNESS TESTER



Applies 1 to 10,000 gram loads

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Use the BARBER COLMAN *Impressor*

on ALUMINUM COPPER BRASS BRONZE and PLASTICS

for Fast and Efficient HARDNESS TESTING

Works on the principle of forcing a hardened, spring-loaded steel point into the surface, the amount of penetration registering instantly on a dial indicator to give a dependable measure of hardness. Operator simply places Impressor on surface and presses down firmly. Can be used in any position, even against edges or ends of pieces when stacked. Requires little effort, ideal for women inspectors. Strongly built for durability and consistent accuracy. Thousands in use. *Comes in velvet-lined, fitted wood case with extra point and full maintenance instructions.* Write for Bulletin F-1689-1.

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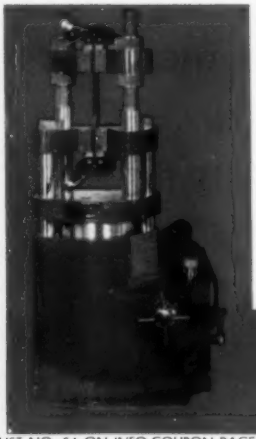

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Whether your testing problems involve the tensile strength or Brinell hardness of metals or component parts, Detroit Testing equipment will speed your operations. In fact, on any tests involving metals, consult Detroit Testing—or write for informative literature.

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*PRODUCTION PROVEN — 30% More Footage!

These Tubing Rolls, made of ARDCORLOY* — a special alloy steel, were designed and manufactured by ARDCOR for one of America's leading Welded Tube Manufacturers (name on request).

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NATIONALLY KNOWN BRANDS

BELOW MILL PRICES

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Stainless Steel in strip, sheet, bars, tubing and accessories.
Cold Finished Steels in all standard shapes and carbon analyses.
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"SILVERCOTE"®
BERYLLIUM COPPER
Hardenable & Tempered
ALSO OTHER NON-FERROUS
WIRES
for
★ SPRINGS
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with 3 DIMENSIONAL
Rigidized
Metals
You'll get:
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your comprehensive independent source of magnesium alloy
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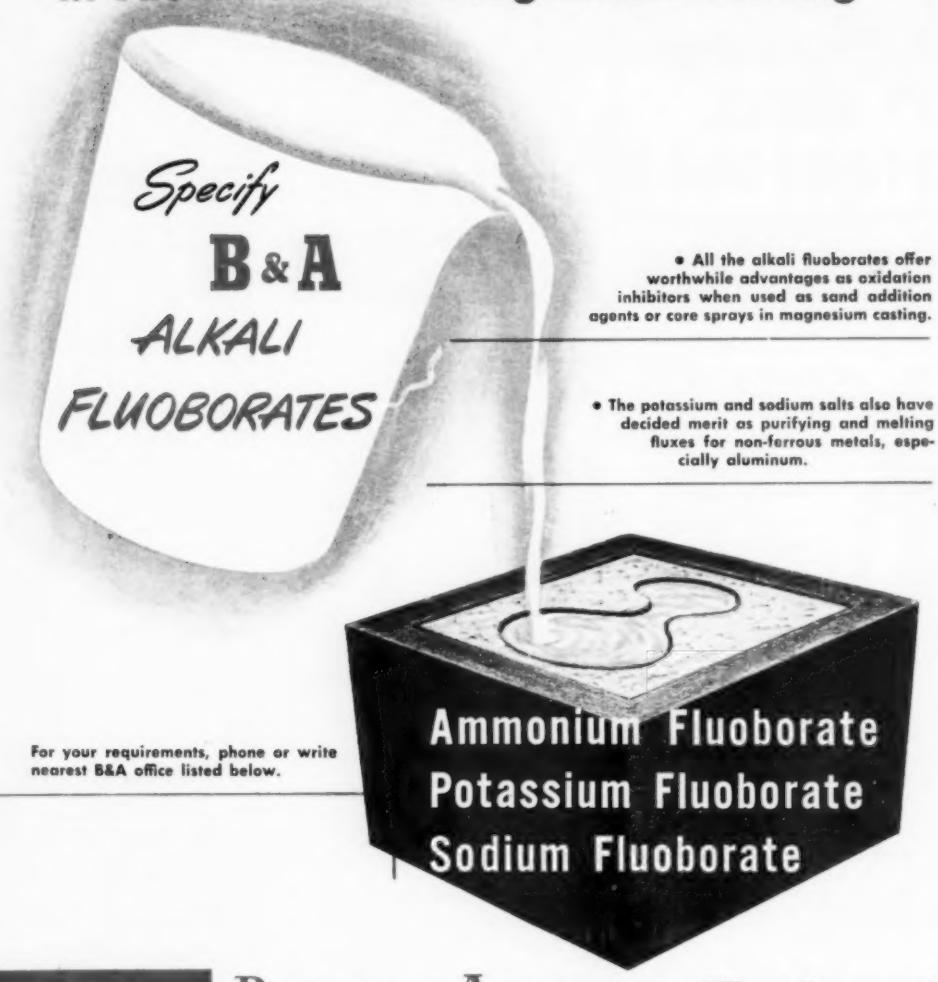

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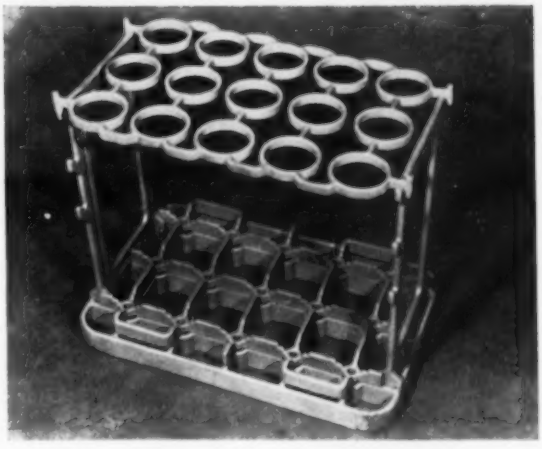

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for Data Sheet on Jet Engine Alloys

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163	313	600	1150	1700
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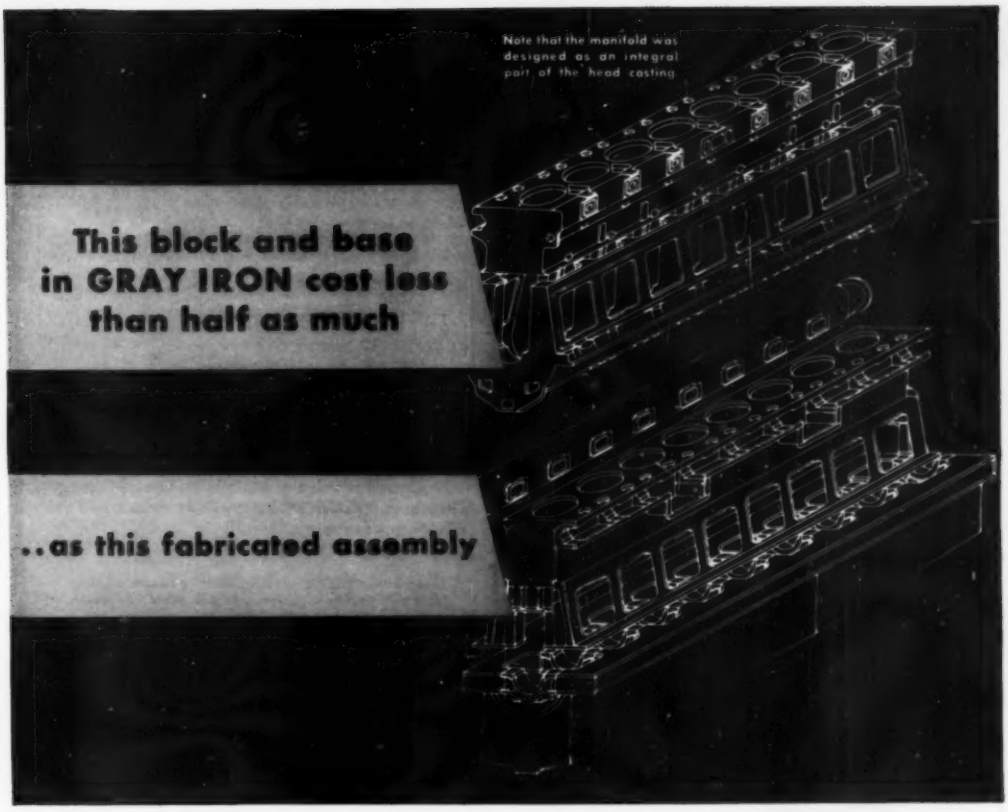
Note that the manifold was designed as an integral part of the head casting
This block and base in GRAY IRON cost less than half as much
..as this fabricated assembly

You can't afford to pass up savings like this!

GRAY IRON CASTINGS COST LESS than fabricated assemblies in over 90 per cent of the cases studied by the manufacturer of this well-known diesel engine (name on request). Shop records of this manufacturer indicate that average savings of 50% can be obtained by using castings.

BETTER STILL—GRAY IRON GIVES YOU MORE ADVANTAGES than any other single production material or method of production: Castability, Rigidity, Low Notch Sensitivity, Wear, Heat and Corrosion Resistance . . . Durability . . . Vibration Damping . . . Machinability, Wide Strength Range.

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SCRAP IS NEEDED FOR DEFENSE—KEEP IT MOVING!

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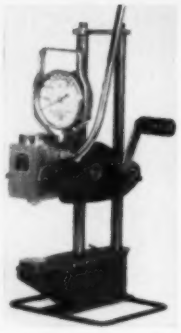
KING PORTABLE BRINELL

HARDNESS TESTER



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This 27-lb. portable tester has a 4-in. deep throat and a gap 10 in. high. For larger pieces, the test head is easily removable for testing sections beyond the capacity of the standard base.

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Simple to operate, the tester is impossible to overload, and even with inexperienced operators will provide consistent accurate results well within the requirements of the Bureau of Standards.

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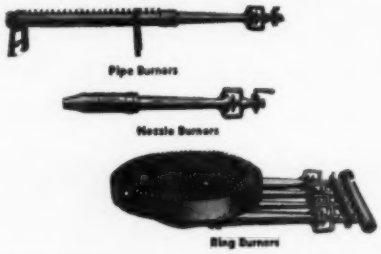
For Many Industrial Gas Uses

NO BLOWER or POWER NECESSARY
. . . just connect to gas supply



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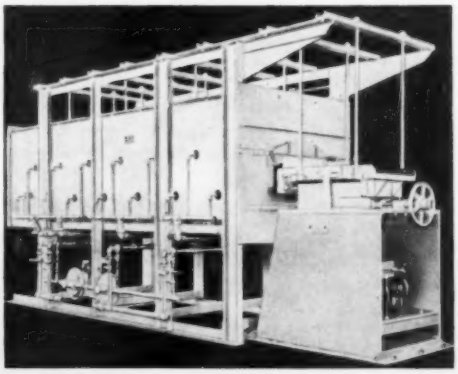
Continuous production installations employ versatile A.G.F. Reciprocating Furnaces such as the No. 191 shown at right to carburize parts of various sizes and shapes.



Batch type vertical furnaces such as the No. 31 Carburizer at the left are used advantageously for uniformly carburizing long work such as oil equipment tools, etc.

Write for complete literature today.

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THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

GA Q-ALLOYS GA X-ITE GA Q-ALLOYS GA X-ITE

TOP "SHOW": Maestro Bill Eisenman and Staff outdid themselves in three dimensions in their "production" of the National Metal Exposition and Congress and World Metallurgical Congress in Detroit.

ALLIES: Eminent metallurgists and engineers from the *living* countries of the *FREE* world made stimulating contributions. In science and technology, the brotherhood of man reaches heights never attained in politics. Certainly those returning from the "Arsenal of Democracy" should carry news and *convictions*. The vitality of the Motor Capital and geometrical *growth* (as apart from mere expansion) of our metallurgical industries never cease to stimulate and impress even those of us who have grown up with Detroit and with the A.S.M.

SHARING ACHIEVEMENT: The growth of these institutions is a reflection of the growth of men, achieved through typically American TEAMWORK. Meeting our third generation of ASM'ers, we are filled with reminiscence, coupling the names and memories of departed A.S.M. Pioneers with their maturing colleagues still in harness and with their sons carrying on. W. P. (Bill) Woodside, one A.S.M. Forefather still in there pitching on his third (or maybe fourth) war, is singularly honored as one of few living men to whom a monument has been erected.

RECOGNITION: Few Engineering Professions have advanced as consistently and impressively as the American Metallurgist, increasingly finding his way into top management and Defense councils. The American Society for Metals has been a major factor in propagating the Metals Arts and Sciences, bringing tangible recognition to their practitioners, and expediting U.S. security.

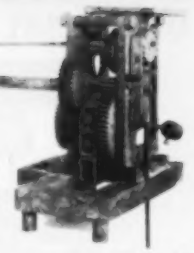
THE N.K. FACTOR: Gratifying is the continued reduction in our *N.K. Factor*. (Negative knowledge—the stuff we all "know" that jest ain't so.) Even the foundry industry with its roots deep in centuries is discovering fundamentals which render obsolete some ancient and largely current practice. The next metals *revolution* is in casting process. Publicized foreign progress and its exploitation provide a new and needed stimulant.

BUREAUCRAPTIC CONSTIFUSION: Government restriction on 35 Ni, 15 Cr welding rod and recommendation that nickel-base alloys be welded with 25 Cr, 25 Ni —we still have a rising regard for most Government personnel with whom we are working. Many Government representatives visited the Show to learn and more intelligently guide industry through the Snafucillation of "mentored economics".

CONSISTENCY: A sure sign of good business is that few alloy casting producers exhibited. Backlogs in good times and the lack of same in slow times prompt some to oscillate in and out of the Metal Shows. General Alloys (the only continuous exhibitor of alloy castings), accepting the responsibility of leadership, has presented the largest alloy casting exhibit "in front of the main entrance" for 33 successive years. A.S.M. has stuck with us, and we stick with A.S.M. Quid pro quo!

"P.A." SCORES WITH G.A.: Don Hutchins, Assistant Vice-President of G.A., Manager, Detroit Office (formerly Director of Purchases at Packard Aviation), is an Engineer with a broad background in production, technical evaluation, and procurement. Don, through buying, and keeping RECORDS on alloy castings, knows the high cost of "cheap" alloys. After 18 months in Detroit, Don is doing a job that would have delighted Al Grinnel, who blazed the Q-Alloy & X-ite trail in Detroit. Advanced Engineering and Product PERFORMANCE help.

"APCRAY APSCRAY": The Government-induced high increment of "scrub-scrap" in recent alloy castings has made buyers acutely aware of the greatly varying performance expectancies resulting. The integrity of the Producer is reflected in the CHARACTER of his product.



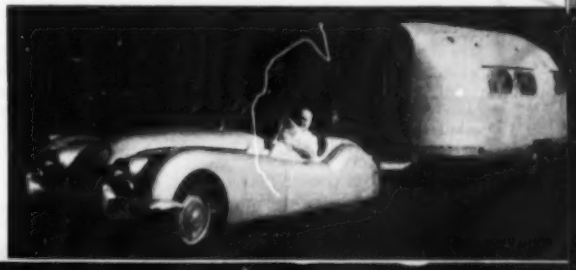
This close-dimensional as-cast Q-Alloy clock **kept time at 2000° F** at the 1928 A.S.M. Philadelphia Show years and years before the so-called "Precision" castings of the dental trade entered industry, and is still, we believe, the most complex mechanical application of cast-to-final-form castings.

G.A. chose to curtail production, rather than impair quality and service DEPENDABILITY by melting the "Scrub-Scrap" available. That situation is currently more intelligently administered. By the way, does anyone remember what became of those "articulated trays" dreamed up as foundry "squeezer" jobs and palmed off as "bargain" substitutes for G.A. hinged trays?

POLITICAL: Comment overheard at the Metal Show, "If all political 'fleas' lost their dogs every four years before they dug-in and multiplied, the tax bite would draw *less blood*." To Republicans needing a campaign song, we offer "Too Damned Long" to the tune of "Three Blind Mice". (Try humming it. If you can't write at least two verses to that, you have "earned" your new tax rate.)

SAIL PLANE ON WHEELS: If you recognize Brain vs Bulk in planes, cars and alloy castings, you'll appreciate the Engineering Integrity of a 19 ft. trailer that weighs 1220 lb. (90 lb. on hitch), and travels 100 m.p.h. behind a "Jaguar", having no "authority" over the car at any time. The "Teardrop", designed by famed Glider Designer Bowlus, is a fully-stressed-skin heat-treated Duralumin nacelle on a chrome-moly tube girder frame, carried on underslung springs and axle, wire wheels and Firestone racing tires. Built like a racing yacht cabin, it has a nose-door, galley, cabin and separate stateroom. Sleeps 4, dines 6. Shower, gas stove and ice-box, highway phone and dictating machine, circulating heater ("gadgets" add 230 lb.). Behind a Cadillac, it smooths wake, *adds* speed. We whisked it from California behind the Jaguar. Many have asked for the "Low-Down" on the "Jag". We'll report later, and also on the new, larger "Airstream" all-aluminum G.A. "Field Engineering Office", carrying advanced casting technology to Defense Industry. Towed by a "souped" Cadillac, it has complete facilities including sound movies and stereo projection and is as independent of public utilities as a Jack Rabbit.

An "Aditorial" by the President of General Alloys Company, "oldest and largest exclusive manufacturers of heat and corrosion-resistant alloys"—Boston, Mass. U.S.A.—Branch offices or representatives in principal cities.



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It Will Pay to Make Your Own Tests with

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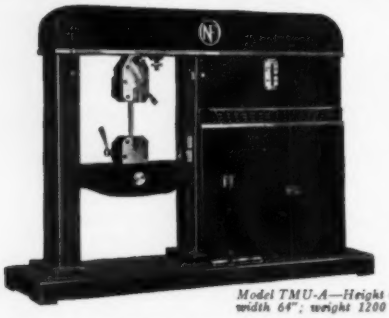

Model TMU-A—Height 44"; width 64"; weight 1200 lbs.

The National Forge Universal Testing Machine, Model TMU, is compact, accurate, dependable, easy to operate and moderately-priced.

Wide working clearances, long stroke, quick-action simplified variable-speed control, improved grips and a wide spread of load scale ranges adapt this modern, streamlined unit to production, research or school instruction tests of a great variety of materials and specimen sizes. A.S.T.M. accuracy requirements are guaranteed.

Three load scale ranges: Model TMU-A—0-30,000, 0-6000, 0-600 lbs. Model TMU-B—0-15,000, 0-3000, 0-300 lbs.

Prompt deliveries of few units remaining in stock.

For details, write for Brochure 501.

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TRACERLAB's new model, non-contacting Beta Gauge measures and records the weight per unit area or thickness of sheet materials. Because beta radiation is used, a high degree of accuracy and sensitivity is achieved, unaffected by variations in chemical compositions of the material being gauged.

Tracerlab developed the first Beta Gauges, and the experience gained through having these instruments in successful, everyday operation in a number of diversified process industries has now been incorporated in a new and outstanding gauge. Featured are simplicity of operation, ruggedness of design and reliability of operation — all combined in an instrument that maintains Tracerlab's established leadership.

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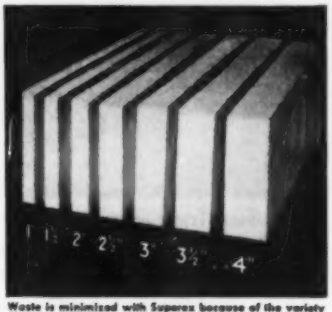

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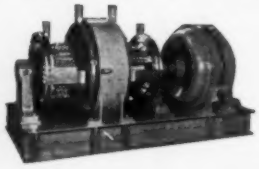

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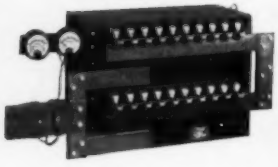

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Required by the Act of Congress of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (39 U.S.C. 233), of **Metal Progress**, published monthly at Cleveland, Ohio, for October 1, 1951.

1. The names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; Editor, E. E. Thum, 7301 Euclid Ave., Cleveland 3, Ohio; Managing Editor, E. E. Thum, 7301 Euclid Ave., Cleveland 3, Ohio; Business Manager, W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.

2. That the owner is: The American Society for Metals, 7301 Euclid Ave., Cleveland, Ohio, which is an educational institution, the officers being: President, W. E. Jominy; Vice-President, John Chipman; Secretary, W. H. Eisenman; Treasurer, R. L. Wilson; Trustees: A. E. Focke, T. G. Digges, J. B. Austin, Elmer Gammeter and J. T. MacKenzie. All officers as above, 7301 Euclid Ave., Cleveland, Ohio.

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4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

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Editor.

(Seal)

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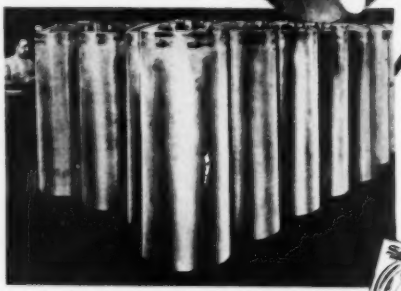

The function, scope, mechanics and economics of Spincraft metal spinning and fabricating are discussed in this stimulating 40-page, well-illustrated booklet. A copy is yours for the asking.

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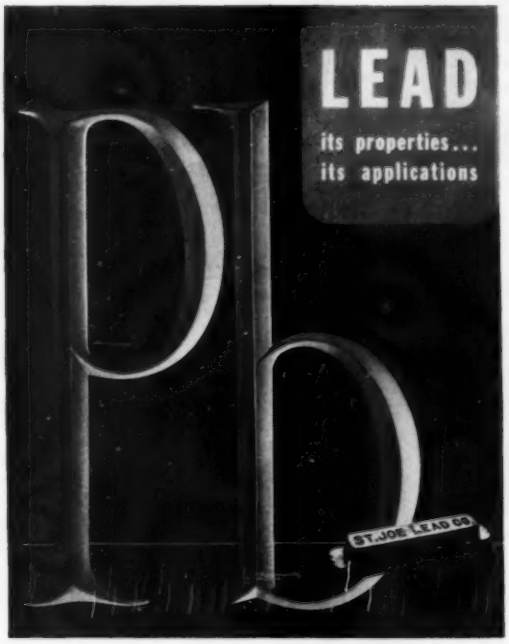

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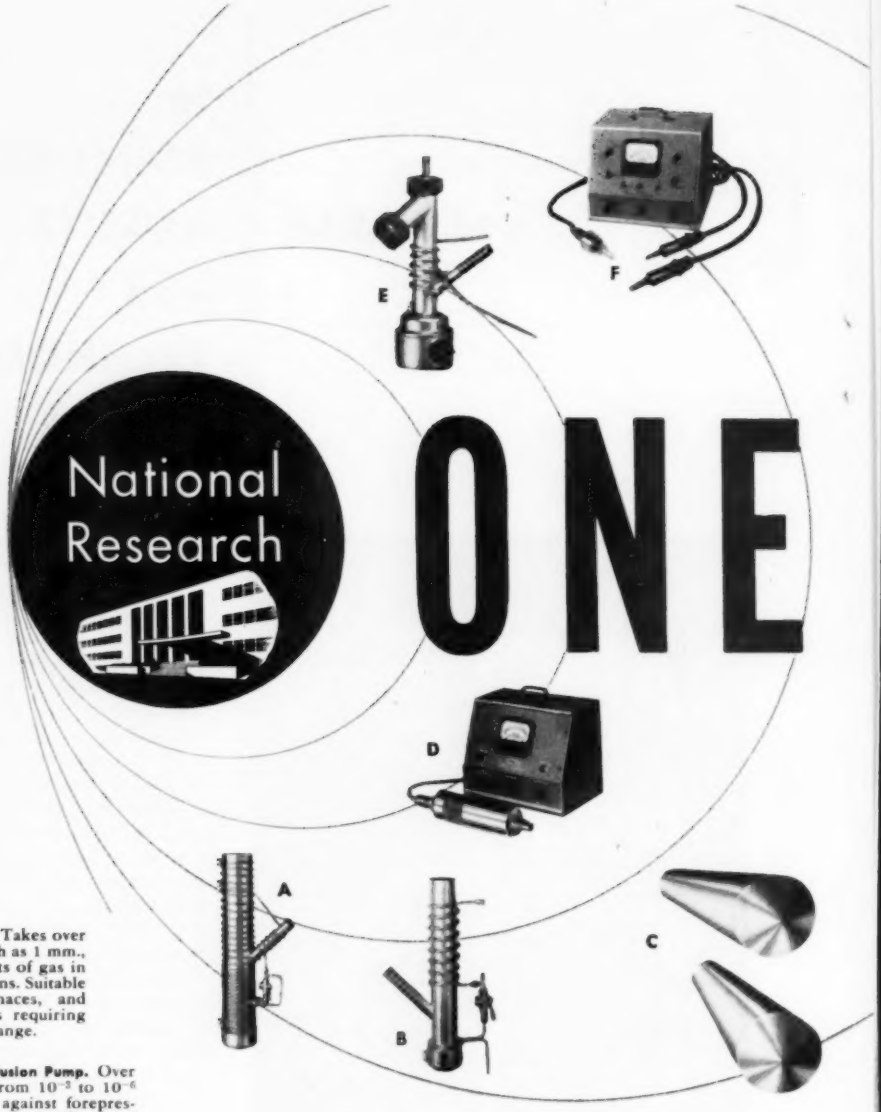

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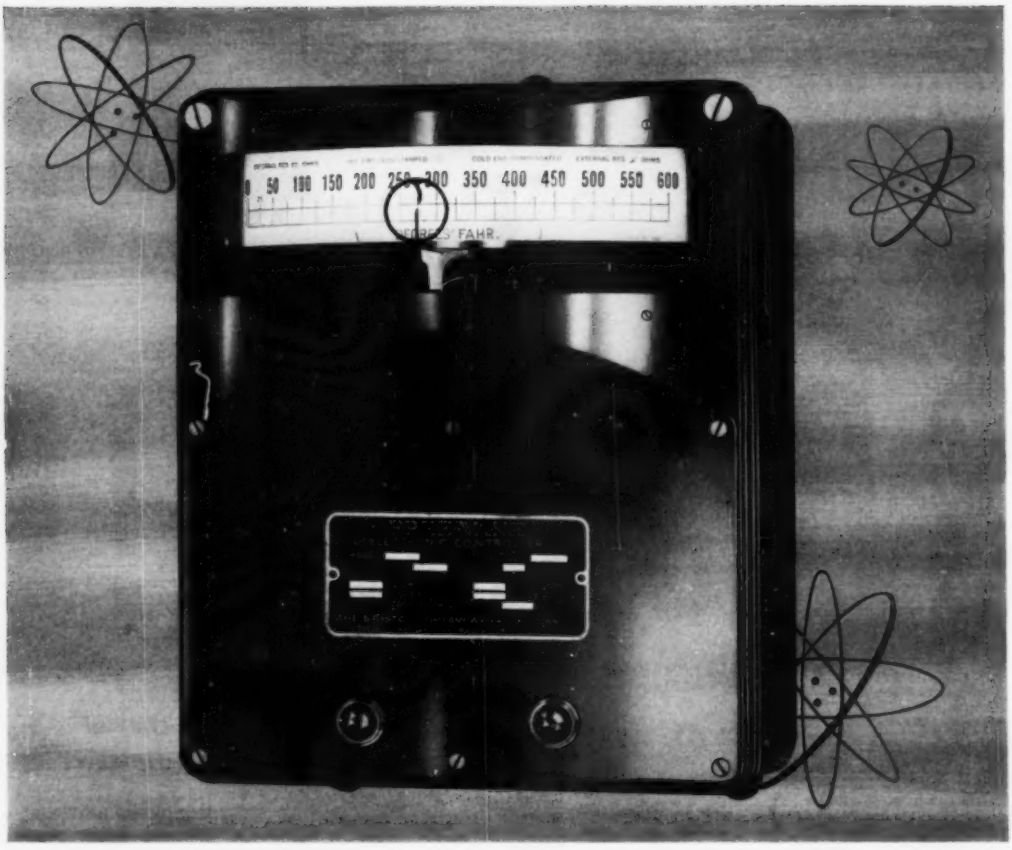

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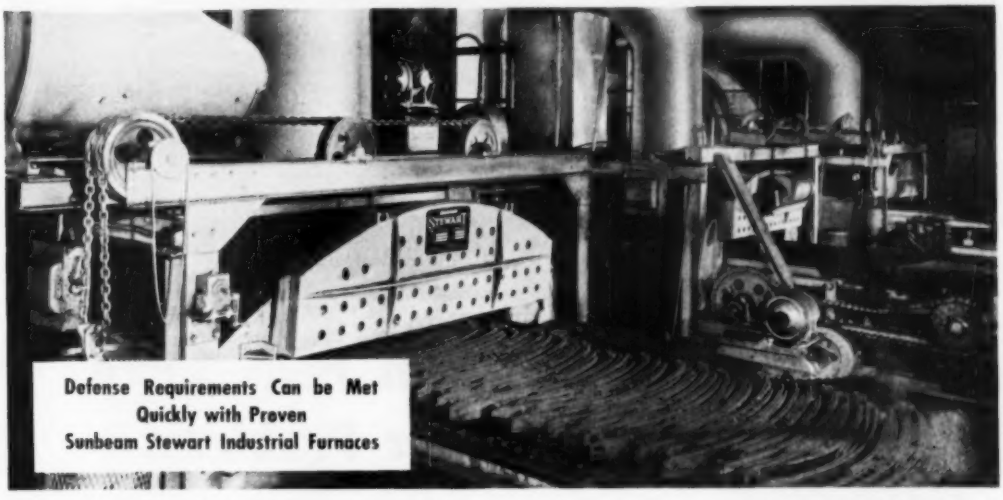

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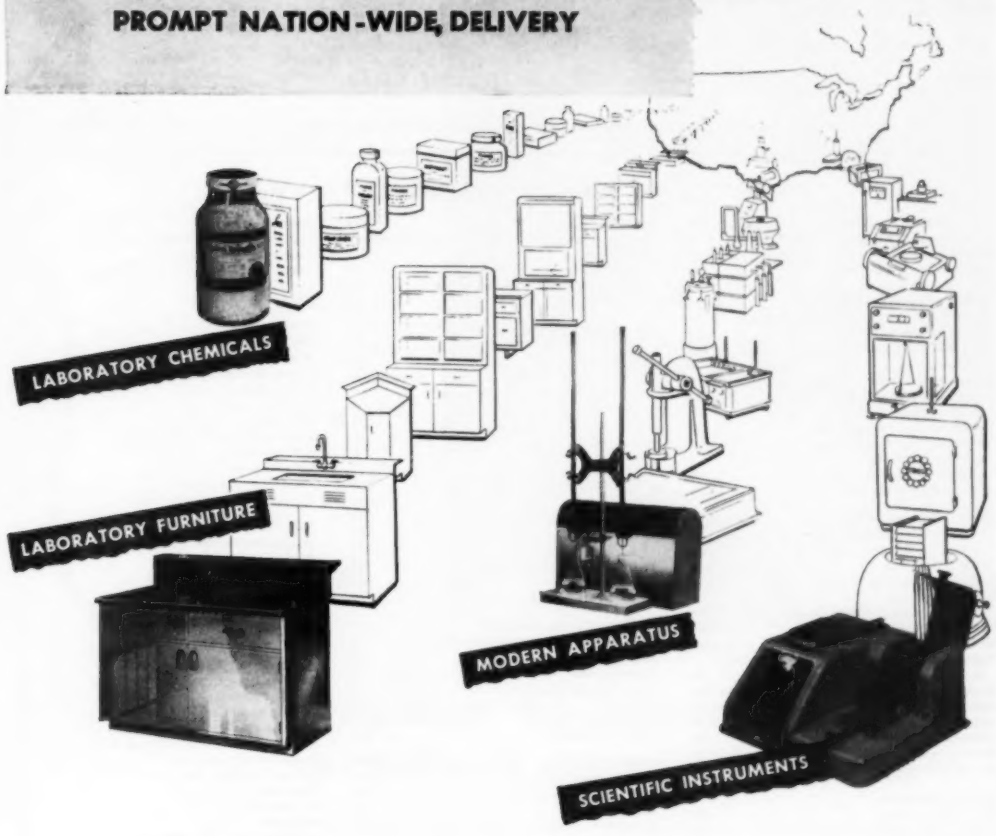

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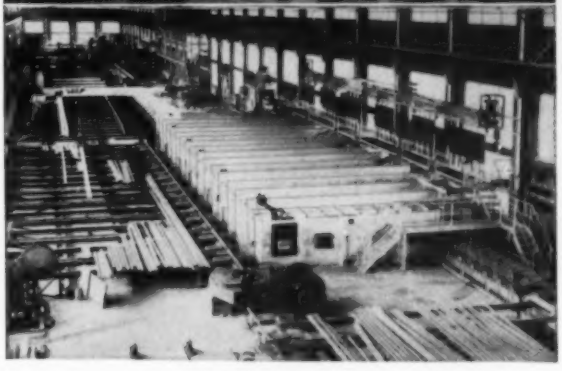

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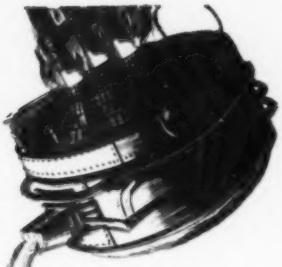

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